ECONOMIC GEOLOGY

WITH WHICH IS INCORPORATED

THE AMERICAN GEOLOGIST

VOL. III AUGUST–SEPTEMBER, 1908 No. 6

THE OCCURRENCE AND GENESIS OF THE MAGNETITE ORES OF SHASTA CO., CALIFORNIA.

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INTRODUCTION.

The magnetite ores of Shasta Co. are found in the formations lying along the McCloud River. The known outcrops and prospects of this ore form a chain that can be traced more or less continuously for twenty miles from south of the Pit River almost

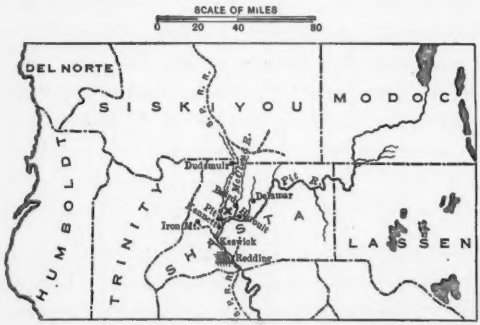


FIG. 39. Sketch map of Northern California showing location of Heroult and adjoining towns.

due north to the edge of the Redding quadrangle where they cease, probably more from the lack of information than from lack of occurrence. The particular deposits described here are

situated northeast of the junction of the Pit and McCloud rivers and about a mile east of the United States Fishery at Baird. They are reached by the Sacramento Valley and Eastern Railroad running from Pit Station on the Shasta Route of the Southern Pacific to Copper City and Delamar on Squaw Creek. See sketch map, Fig. 39.

The adjacent country is noted for its productive copper and gold mines, and it is from prospectors searching for these metals, and from the occasional demand of the copper smelters for basic flux, that the iron has received in the past even the small attention given it. The cost of fuel and the lack of the facilities for transporting the finished product to the market prohibited any thought of these deposits yielding blast furnace iron, but recently a company has been formed to smelt this ore by heat generated from electricity, and the success of this venture means the establishment of a new industry in California. The progress made in this line has been followed by the electrical and metallurgical press, and to such publications the reader is referred for further information.

The field observations on which this paper is based were made by the writer during an examination of the property of the Noble Electric Steel Co. in the winter of 1907–'08, and the results are published here with the consent of the manager, D. A. Lyon. Thanks are also due Wm. Bjorkstedt, chemist for this company, and H. R. Moss for analyses, and Dr. A. F. Rogers, of Stanford University, for many helpful suggestions.

TOPOGRAPHY AND GENERAL GEOLOGY.

Topographically the most important feature of this immediate region is a ridge of metamorphosed limestone. This white crystalline mass resists erosion to a much greater degree than the surrounding igneous rocks, and rises to a prominent jagged crest from 2,000 to 2,500 feet above the bed of the McCloud River, which parallels its strike and gives it its name. The continuity of this outcrop is broken in places by the associated intrusives, and the streams trending westerly have taken advantage of the

softer
River l

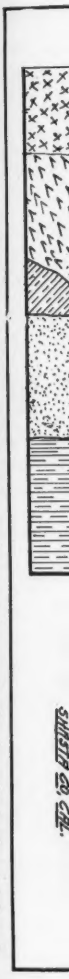


Fig. 40. Sketch map and columnar section showing the geology of the magnetite deposits in the vicinity of Heroult, Shasta Co., California.

softer rocks in these gaps to cross this formation. The Pit River lies in such a gap, and from its junction with the McCloud

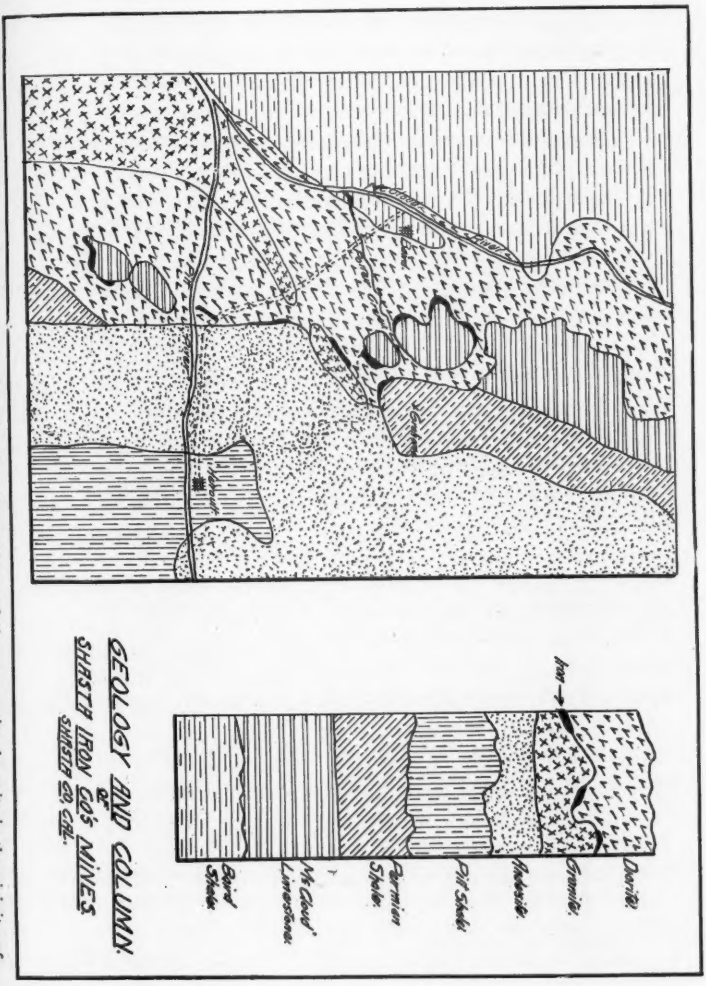


FIG. 40. Sketch map and columnar section showing the geology of the magnetite deposits in the vicinity of Heroult, Shasta Co., California.

a ridge of granitic rock extends northwestward to the northerly continuation of the limestone and forms the divide between the drainage of the two streams. East of this ridge the topography is rough and irregular; numerous short streams lead from the highlands to the cañon-like valley of the Pit, while to the west the McCloud reveals its history in the benches and cuts it has formed in reaching its present level.

The main features of the geology are shown on the accompanying geological map, Fig. 40.

The stratigraphy of this region has received the care and attention that it merits, and the results of this work may be found in the Redding folio by Diller,[1] and the papers of J. P. Smith[2] and Fairbanks.[3] The general dip of the strata is steep to the east, and in going from the Little Sacramento up the Pit River valley one may, by choosing his route, pass successively through the Devonian, Sub-Carboniferous, Carboniferous, Permian, Triassic and Jurassic. Separating the Permian and the Triassic sedimentaries is an area of Triassic andesite and rhyolite, while between the upper Carboniferous, the McCloud limestone, and the Sub-Carboniferous, the Baird Shale, is an outcrop of diorite of early Cretaceous or late Jurassic age. This mass of diorite presents two phases, an earlier granitic one already noted as forming one of the prominent ridges, described by Diller as a quartz-hornblende-diorite, and a distinctly later, fine-grained variety referred to in the same folio as a quartz-augite-diorite. The latter appears to be a great irregular dike intruded along the McCloud limestone during the mountain-making disturbances that marked the period to which it has been assigned. This quartz-augite-diorite is the one constant factor in all the iron deposits forming at least one wall of the mineralized zone, and as frequent reference will be made to this formation, it will be

[1] Redding folio, U. S. G. S. Atlas of U. S. folio No. 138.

[2] "The Metamorphic Series of Shasta Co., Cal.," *Jour. Geol.*. Vol. II., 1894. "The Carboniferous strata of Shasta Co.," abstract *Am. Assoc. Adv. Sci. Proc.*, Vol. 43, 1895.

[3] "Geology and Mineralogy of Shasta Co.," Cal. State Min. Bur., 11th Rept., 1893.

designated the *diorite,* as distinguished from the earlier granitic type, the *grano-diorite.*

Detailed petrographic description of igneous rocks of this district may be found in the government publications on the quadrangle, the following brief treatment of those genetically connected with the iron ore will serve our purpose of classification.

The Triassic andesite is a greenish-grey sub-porphyritic lava, with phenocrysts of both plagioclase and augite, the latter almost invariably showing much alteration to chlorite. The minerals of the ground mass are scarcely distinguishable, though they appear to be chlorite, epidote and the feldspars. In the field the rock is readily recognized by its porphyritic appearance, while weathering accentuates its contrast with the associated diorite.

The grano-diorite is a coarse, even-grained rock largely made up of light-colored minerals, but with a liberal sprinkling of dark ferro-magnesian compounds. Under the microscope the feldspars are found to be deeply kaolinized, but both plagioclase and orthoclase can be distinguished, quartz is abundant and hornblende and magnetite are lesser constituents. This rock gives as a decomposition product the usual light-colored gravelly soil characteristic of granites, and its area may be easily traced by this where the outcrops are lacking.

The diorite is a very fine even-grained light to dark rock, with an uneven fracture. The mineral composition cannot be distinguished with a hand lense, but under the microscope it proves to be holocrystalline. The original minerals were probably plagioclase, quartz, augite and some orthoclase, though many sections show only quartz, epidote and some altered feldspar. As would be expected in an intrusion of this nature, there is considerable variation shown in different sections, some having marked diabasic structure and arrangement of the feldspars. It weathers readily to a red soil that supports an abundant vegetation, and as outcrops of fresh unaltered rock are rare, some difficulty was experienced in tracing its boundaries accurately.

Skarn[1] is a very close-grained dark-green rock seamed with

[1] Skarn is defined in a paper by Hjalmar Sjögren entitled the "Geological Relations of the Scandinavian Iron Ores" as a name for rocks of varying composition mostly consisting of lime, magnesia, iron and alumina silicates

epidote and pyrite and associated with garnet and magnetite. A fracture often shows slickensided surfaces due to a coating of chlorite or similar secondary product. In a thin section it shows augite, and hornblende with a ground mass composed largely of chlorite, epidote and some feldspar especially near the magnetite. The term skarn is not at present used by American geologists, but expressing as it does a certain series of rock-forming minerals with a definite relation to the ore, it would seem to merit a place in the vocabulary of the mining engineer and economic geologist.

The one sedimentary that has a bearing on the genesis of the iron is the McCloud formation, a light-colored massive, exceptionally pure limerock that is shown by numerous analyses to contain nearly 96 per cent. of the carbonate of lime, the remainder being largely silica and magnesia with some alumina and iron. It has suffered almost complete metamorphism to fine-grained marble, but in a few localities distinguishable silicified fossils are found with small nodules of chert, and these with the fossiliferous horizons above and below have served to place its age as Upper Carboniferous.

OCCURRENCE OF THE ORE.

Deposits of magnetite between an intrusion of igneous rock and a limestone are a very common occurrence, so much so that there has been a tendency to group them under a separate head in a general classification of ores. Some time ago it was pointed out that this led to confusion, as some seemed to expect all iron deposits so located to show the same phenomena, irrespective of whether they were sediments subjected to regional metamorphism, or the direct product of contact activity, and hence they are now more accurately designated according to their type of genesis. But the original tendency still manifests itself in calling the group contact limestone deposits, whereas the limestones have really very little genetic connection with the ore and the deposits are certainly not limited to their contacts.

of the pyroxene-amphibole and garnet groups and is "scarcely an independent rock but is connected with ore deposits." *Trans. Am. I. M. E.*, Nov., 1907, p. 881.

This fact is well illustrated in this locality, for here we find magnetite bodies developed between the diorite, the most recent rock, and the grano-diorite, andesite, and shale, as well as the limestone. Certain selective tendencies seem to have resulted in a fairly constant order of magnitude for these deposits. The ore bodies at the andesite-diorite contact are rare, and as far as developed are small, the largest about 150 feet in length and varying from a few inches to a few feet in width and those at the shale-diorite contact are irregular bodies seldom more than a few feet along their greatest dimension. But at the grano-diorite-diorite contact well-developed deposits of several hundred feet in length and perhaps fifty feet thick are found, and at the limestone-diorite contact these dimensions are often doubled. This corresponds to the degree of metamorphism that these various formations have undergone, for the shale and andesite show upon examination with a hand lens little change from contact action, while the grano-diorite has a well-marked zone of much altered rock, and as would be expected, the limestone bears signs along its border of the greatest mineral change of all.

The interrelation of these rocks clearly fixes the age of the ore as contemporaneous with the cooling and solidifying of the intruded diorite. It could not well be earlier than this, for the ore is at no place cut by the main mass of this igneous rock as are all other formations. If considered later, it would be necessary to account for its strict confinement to the contacts of this one rock, and the fact that the ore is cut by small dikes a few inches in width that seem to be connected with the last stages of the cooling of the magma.

The property of the Noble Electric Steel Company, called the Shasta Iron Mine, contains one of the most promising prospects in the district, and as it has been developed to some extent, it offers the most advantageous location for more detailed study. The main ore body lies next the pure limestone at right angles to the crest of a sharp ridge above Potter Creek, and outcrops with a width of over 100 feet for at least twice that distance on either side of the divide. The ore has been exposed principally by means of a quarry, but several short tunnels have been driven

into the contact zone 100 to 200 feet below the highest point of the outcrop. Below, in Potter Creek, a second quarry has been opened in the limestone at the contact, and numerous small pits and prospects outline the boundaries of this rock. The minerals developed with the ore and exposed in these various workings are typical of contact metamorphic deposits, and their chemical composition and occurrence give us evidence of prime importance in reaching conclusions concerning their genesis and that of the ore.

MINERALOGY.

Magnetite is the only mineral of economic importance. It occurs in masses of remarkable purity, part of which are composed of a close aggregation of partially formed coarse crystals, whose condition may have been the result of rapid deposition in a restricted space and under great pressure, while other portions approach a massive condition, though close scrutiny will usually reveal a crystalline structure. In certain localities large rhombic dodecahedral crystals have been developed measuring over five centimeters along the major diagonal of the rhomb face. Much of the magnetite is polarized, and has a marked attraction for its own powder, but so far it has not been possible to formulate a law governing the occurrence of this lodestone with reference to the ore bodies, though such a law might prove invaluable in developing and prospecting. The analysis given below is from an average sample of a several hundred ton shipment from the main property, but while it shows the comparative purity of the great masses of ore, it is not an analysis of the magnetite as a mineral. No titanium or titanium minerals have been found.

ANALYSIS OF THE IRON ORE BY WM. BJORKSTEDT.

Fe_3O_4	89.4
Fe_2O_3	7.5
MnO	0.18
CaO	0.00
MgO	0.3
SiO_2	2.4
P	0.011
S	0.009
	99.800

Garnet occurs both crystalline and massive; the former is found in many different deposits, the latter confined to those between the limestone and diorite, and, more strictly speaking, to that portion of this zone between the magnetite and the lime-rock. Good crystals are rare, but granular masses composed of small dodecahedrons reach several feet in thickness, and as small lenses and streaks are widely distributed. The massive garnet occurs associated with the skarn between the iron ore and the diorite in many of the deposits of the district, and forms a hard compact brownish rock difficult to drill and very resistant to erosion. The analysis[1] of the crystalline garnet which follows is a recalculation from a quantitative determination of iron and lime and a qualitative test for alumina, and shows the mineral to be 91.5 per cent. andradite and 9.2 per cent. grossularite.

RECALCULATED ANALYSIS OF THE GARNET.

CaO	34.0
Fe_2O_3	28.8
Al_2O_3	2.2
SiO_2	35.7
	100.7

Hedenbergite occurs only in the deposits next the limestone and then close to the contact with this rock. It is green, fibrous or columnar, with the aggregates always perpendicular to the plane of the contact, and in places attains a thickness of several feet. It alters readily, and pseudomorphs of limonite after hedenbergite are found in all stages of the change. The analysis is by Wm. Bjorkstedt.

SiO_2	46.4
Al_2O_3	0.6
FeO	22.6
MnO	7.9
CaO	20.5
MgO	2.2
	100.2

Ilvaite is a rare acid silicate of lime and iron. It seems to be limited in its occurrence to contacts of igneous rocks and lime-

[1] Wm. Bjorkstedt. Fe = 20.1, CaO = 34.0.

stone and is quoted by Lindgren[1] as one of the typical products of contact metamorphism. For this reason it is of particular interest aside from its rarity. It is iron-black, submetallic, brittle, has a green streak, and occurs both massive and in small orthorhombic crystals, the latter intimately associated with a narrow growth of quartz crystals both included in them and deposited on their surfaces. The crystal forms are listed and drawings are given in a recent article in the *American Journal of Science*.[2]

The massive ilvaite occurs in a band half an inch or more in width and occasionally in irregular prisms of rectangular cross-

FIG. 41. Sketch of specimen of contact between diabase and limestone showing development of contact minerals. White areas = limestone; fine dotted areas = garnet; coarse dotted areas = diabase; black areas = ilvaite. Five-ninths actual size.

section penetrating the limestone at its contact with a six-inch diabase dike. See Fig. 41. The analysis given here was made by H. R. Moss on material selected from this massive occurrence.

ANALYSIS.

SiO_2	28.09
Fe_2O_3	20.80
Al_2O_3	0.32
Cr_2O_3	0.13
FeO	29.93

[1] Lindgren, "The Character and Genesis of Certain Contact Deposits," *Trans. Am. Inst. M. E.*, Vol. XXXI., p. 227.

[2] Prescott, *American Journal of Science*, July, 1908.

MnO	3.24
CaO	15.89
MgO	0.18
H_2O	1.62
	100.20

Quartz, epidote, tremolite, calcite, pyrite, chalcopyrite, limonite and hematite have also been distinguished. The sulphides are found sparingly disseminated through the ore as a primary constituent, and in large masses as a secondary deposit associated with calcite and hematite. The limonite and hematite are always secondary and result from the alteration of the abundant iron minerals, but not in sufficient quantities to form any economic deposit. These minerals will be described further as occasion demands.

PARAGENESIS OF THE MINERALS.

The paragenesis of these minerals is in some cases simple and in others it was impossible to determine the relation with any degree of accuracy. Undoubtedly the first mineral formed was magnetite accompanied by a small amount of pyrite and chalcopyrite, but not in sufficient quantities to seriously affect an analysis of the unaltered ore. Both garnet and hedenbergite are clearly later, but as their inter-relation is not distinct, they are given together as the second product. There is, however, no evidence that the formation of the garnet is limited to this stage; it may have been developed in lesser amounts at later times.

The next to be deposited were the quartz and ilvaite. These are not only contemporaneous, but their formation was perhaps simultaneous. Following these two was probably a great lapse of time before the deposition of the first minerals from the vadose circulation took place. These are calcite, pyrite, chalcopyrite and hematite, and lastly limonite.

No single cross-section of the ore deposit would show all these minerals in their exact relation and sequence, but a generalized section would perhaps show first diorite, next skarn, with massive garnet and lenses of magnetite, then the iron ore, followed by the crystalline garnet or hedenbergite, these in turn by quartz

and ilvaite, and lastly by the lime rock. Either the garnet or hedenbergite may occur directly between the iron ore and the limerock, while the ilvaite is found in one locality between igneous rock and the same formation. It will be noticed that this sequence in the cross-section from the magnetite through to the limerock is identical with the order of deposition as it has been ascertained, and is such as would be found if the deposition of each mineral had taken place directly against the limestone. This same order also shows a transition from the basic, the iron oxides, through the lime-iron silicates to the acid extreme in the quartz.

GENESIS OF THE ORE MINERALS.

The questions now present themselves—first, what material does the replaced limestone supply for the formation of these minerals and what portion of them represent additions from the magma; secondly, what changes in physical conditions are represented by the changes in the minerals formed; and lastly, what is the relation of this class to the general theory of ore deposition.

In a paper in ECONOMIC GEOLOGY for January, 1907, Kemp has shown that the minerals of the contact zone give strong evidence of being additions from the magma, and his method of attacking the problem in that paper is applicable here. The garnet, ilvaite and hedenbergite are all essentially lime-iron silicates with very small percentages of alumina, while the limestone is essentially pure $CaCO_3$ with but a trace of iron and alumina and a small percentage of silica, and when the great mass of magnetite ore is also considered with the silicates, it is at once evident that a mathematical proof is scarcely needed to show that none of these minerals could represent a recrystallization of the limestone. On the other hand, when we remember that the crystalline garnet, hedenbergite, and ilvaite are all limited in occurrence to the contact of the limestone, the question at once presents itself, was not the CaO that makes up a large part of their composition derived from that source? As we have already seen, there seems to have been a removal of limerock perhaps contem-

poraneously with the deposition of each mineral, the carbonic acid probably being driven off and the CaO remaining to be accounted for. As the mineralized zone extends but a few inches into the limestone from the contact, and as there is no evidence of change of composition of this formation, as we pass further into it, we may safely assume that only the portions of limerock replaced entered into the equation, and on this basis may calculate the available portions of the required molecules for a unit of volume.

The analysis given below is by Wm. Bjorkstedt from a sample of the pure limerock unaltered by contact action.

SiO_2	1.2
Al_2O_3	0.5
FeO	0.2
MgO	1.1
CaO	53.8
Loss	43.3
	100.1

AVAILABLE AND REQUIRED AMOUNT OF THE CONSTITUENTS.

	Sp. Gr.	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	MnO	Additional.
Limestone gms. available per c.c.	2.8	.034	.014		.0056	1.51	.031		Loss = 1.21
Gms. required per c.c. for garnet	3.8	1.36	.083	1.09		1.29			
For hedenbergite	3.6	1.67	.022		.74	.72	.073	.28	
For ilvaite	4	1.12	.013	.83	1.19	.635	.007	.13	Cr_2O_3 = .005 H_2O = .065

This table emphasizes the following points. Manganese and chromium are not found in the limestone, but are present in appreciable quantities in certain of the minerals. The amount of silica available is less than three per cent. of the amount required in the most favorable case, while the iron available is less than one per cent. The alumina and magnesia in the limestone correspond fairly well with that found in the minerals, and the lime is present in excess of the required amount. It would seem, then, that since the iron, silica, manganese and chromium are not found in the limestones in sufficient quantities they must have come from the only other available source, the diorite. The

mineralizer that brought them to their present position might also carry away the excess of lime. Indeed it would also seem probable that it would take up portions of the alumina and magnesia, in which case these two would have to be added to the list of those derived from the magma.

The consideration of the changes in physical conditions, as shown in the changes in mineral constitution, presents many difficulties, and results largely in generalities. As Beck[1] has pointed out, it is the mineral associations of the magnetite that enable us to make the distinction between segregation and contact deposits, and if, as in this case seems probable, the various minerals represent slightly later stages than the ore, we find still more difficulty in drawing this line. In any event it would seem, at first, impossible to separate the tendencies which produce the emanation of water gas highly charged with iron, from those that cause segregation of the more basic portions, convection currents, and similar action believed to be present in a cooling magma. On the other hand these segregation tendencies must be given a secondary position in a summation of the factors which controlled the deposition of the ore. Otherwise we should expect to find more continuous bodies of iron at all contacts, the larger bodies associated with greatest mass of the igneous rock, and a zone of disseminated magnetite, and should not expect to find ore bodies occurring near the contact, but separated from it by a small portion of the magma. This latter is most plausibly accounted for by crevices being open during the cooling, and these being used by the mineral-bearing gases as a mode of egress from the still heated interior.

The ilvaite at the other end of the series of primary iron minerals offers a marked contrast with the magnetite in composition and occurrence. The crystals of ilvaite are found in a matrix of quartz crystals and upon their deeply corroded surface, this corrosion being evidence, most probably, of a drop in the saturation of the mineralizer in quartz before the final cessation of the deposition rather than an increase in temperature and pressure. This poverty in quartz was not sufficient to prevent the forma-

[1] Beck-Weed, "Nature of Ore-deposits," Vol. II.

tion of the ilvaite with its relatively small requirement of silica, and its deposition continued for a short interval. The massive occurrence is at the border of a six-inch diabase dike that was probably extruded from the main magma by the stresses set up during the cooling, and, from the presence of water in the ilvaite molecule, it would seem that this dike was probably more highly charged with magmatic water than the main mass. This is in accordance with the recorded occurrences[1] and the theory of the crystallization of igneous rocks. The diabase shows no alteration along the contacts with the ilvaite, as would probably be the case had the ilvaite been deposited by circulating waters, and the mineral has its rough edge next the diabase, the other side showing a tendency toward crystalline form (see Fig. 41). We have then through the ilvaite a genetic connection between the growth of quartz crystals and the igneous activity, which may be used both as additional proof of the fact that we must look to this source for the material in the contact zone, and as a rough criterion of the change in physical and chemical conditions.

The formation of the ore and its accompanying minerals took place, then, under conditions intermediate between those of segregation and those of water solution. The mineralizer was probably water gas at all stages represented by the silicates, for the water must have been above the critical temperature and pressure. A study of these minerals as a series would seem to show a decrease in the intensity of the physical conditions as time elapsed accompanied by an increase in silica content and a drop in iron.

The presence of recrystallized calcite and hematite, with the sulphides in the secondary deposits, would seem to show that these were formed under conditions closely resembling those normally found at the surface.

The relation of deposits of this type to the general theory of ore deposits has been shown by Kemp,[1] and in a more general way by Spurr,[2] both in recent articles. It would seem plausible

[1] Lindgren, U. S. G. S. Prof. Paper, No. 43, 1905.
[1] Kemp, Economic Geology.
[2] Spurr, *op. cit.*, Vol. II., No. 8.

that the same physical conditions which made the deposition of the quartz possible would be reached eventually by the gases in their upward passage from the heated intrusive toward the cooler surface zones, and that quartz veins would result. But the proof that the emanation from a single magma is able to form ore deposits of many metals is not to be gathered from a study of one occurrence.

SUMMARY.

The magnetite ores of Shasta Co. occur at the contact of a diorite intrusion with older formations, the larger ore bodies having limestone for one wall. The deposition of the ore and the accompanying minerals, ilvaite, hedenbergite and garnet, is contemporaneous with the cooling of the igneous rocks. The paragenesis of these minerals shows a transition from basic to siliceous and that each mineral was deposited, in turn, against the limestone. These minerals are essentially lime-iron silicates, the iron and silicate representing additions from the cooling magma, the lime being derived from the limestone. The character of the successive minerals seems to show a change in physical conditions from one closely resembling segregation to one approaching that of water solution. The probability is that the entire series was deposited by water gas given off from the magma, bearing iron and silica.

GEOLOGY OF ILLINOIS PETROLEUM FIELDS.

H. Foster Bain.

HISTORICAL.

The discovery of important petroleum fields in southeastern Illinois, in 1904, came as a pleasant surprise to all but a few persons. Illinois had previously been considered unfavorable ground for prospecting. This was in part based upon unsuccessful trial at a number of points, and in part upon certain misconceptions generally obtaining as to the structure of the state and its relations to the possible occurrence of gas and oil. Previous to the recent discoveries there had been repeated attempts to find petroleum. As early as 1853 marsh gas is said to have been found near Champaign, and following the early discoveries in New York and Pennsylvania, attempts were made at various points to locate commercial pools. These were, however, without notable success, though at that time a dozen holes were put down in the heart of one of our present most productive pools. Small amounts of gas and oil were found but, probably owing to imperfections in drilling methods and to attention being concentrated on the discovery of "gushers," the importance of the finds was not appreciated.

After the great discoveries in the Trenton rock of Ohio and Indiana, another attempt was made to develop Illinois. This met with a little better success, a small pool of heavy oil accompanied by gas being located at Litchfield, in Montgomery county, in 1866. The pool is only about one and one-quarter miles long by a scant three-quarters wide. The gas was soon exhausted but the oil continued to be pumped up to 1902, a total production of 6,576 barrels being recorded. Certain of the wells are even yet capable of yielding a few barrels per day, though they are not now pumped.

About the same time, natural gas was discovered near Sparta,

in Randolph county, and was used locally up to about 1891. The quantity was not great, as gas wells go, and drilling at this time failed to discover oil in paying quantities.

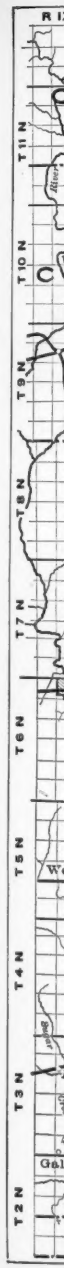
The Pike county gas field was first discovered about 1890, but no attempt was made to develop it prior to 1905. Both the field and the individual wells, so far as at present developed, are small.

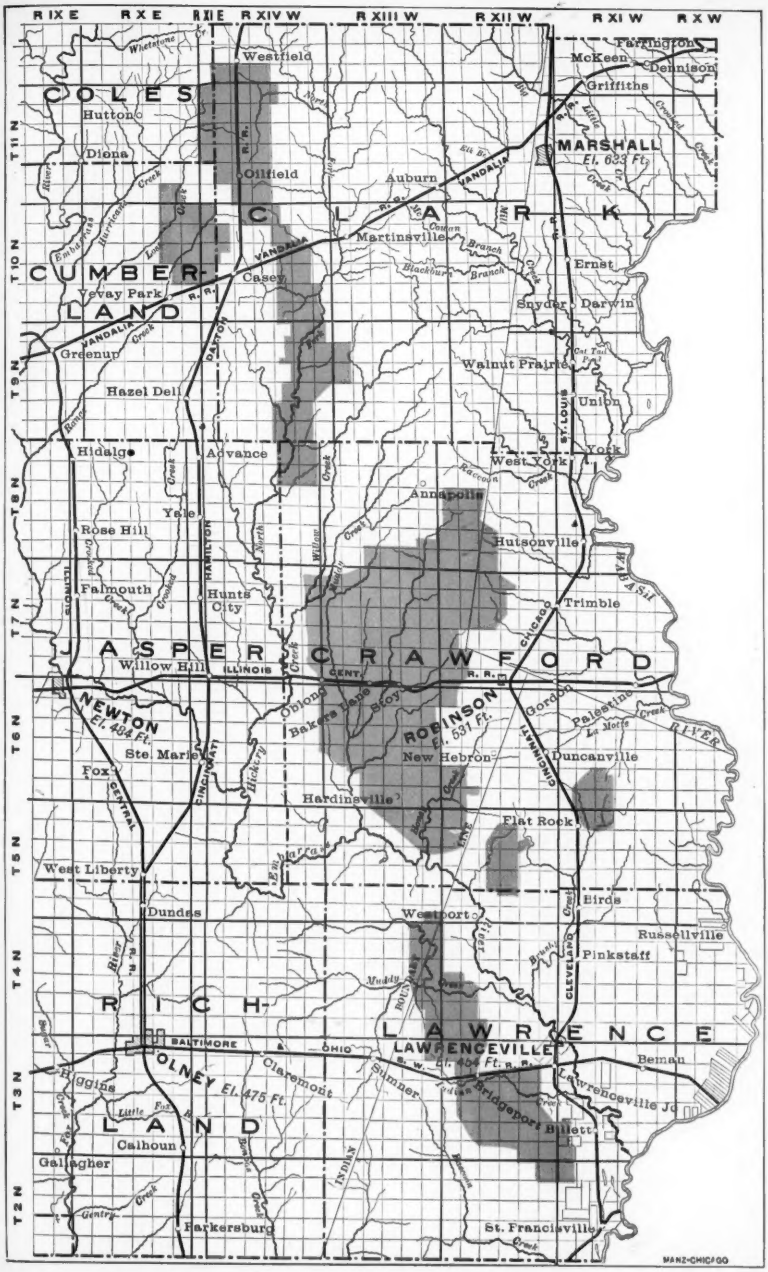
In addition to these discoveries, oil and gas, particularly the latter, were occasionally noted in drilling at widely scattered points, throughout the state. The amount found, however, always seemed small, the local drillers were unfamiliar with the methods of bringing in gas and oil wells, and the public soon settled down to the conviction that Illinois was "not in the oil belt." As a result these finds were not taken seriously and little attempt was made to explore for petroleum.

Early in 1904, J. J. Hoblitzel, an experienced oil producer from Pennsylvania, being attracted by the small amount of gas still flowing from one of the Clark county wells put down in 1865, made a new attempt to develop the field. His first well was a success and others followed in quick sucession. By the end of the year a number of wells had been brought in and in June 1905 shipments began.

Development extended rapidly to the southeast, so that by the close of 1907 the area indicated in plate IX was all under production. Early in 1906 a brief report upon the field as then developed was prepared by Professor W. S. Blatchley and published by the State Survey of Illinois.[1] At that time production were confined to Clark and Cumberland counties, though some wells had been brought in in Crawford county and drilling was being rapidly extended. This report was essentially industrial and economic. Since its preparation numerous geological notes have been accumulated. The present paper is merely an attempt to bring together what is now known. Detailed surveys in the area are still incomplete, a fact resulting from its size, 60 by 18 miles, and the rapidity of the development.

[1] State Geological Survey (Illinois), Bull. 2.





Map showing producing oil pools in eastern Illinois, 1907.

PRODUCTION.

Pipe lines have been rapidly extended throughout the district, and several refineries have been built. The recorded production has been as follows:

PETROLEUM PRODUCTION OF ILLINOIS.

Year.	Barrels.
1905	156,502
1906	4,385,470
1907	24,540,024

At present, June 1908, the pipe line runs approximate 102,000 barrels per day, to which must be added a small amount for tank car shipments and oil used by the local refineries.

The quick development of so important a field in an area previously condemned both by practical drillers and by scientific investigators, has in it certain lessons for the future.

GEOLOGY OF THE EASTERN ILLINOIS OIL FIELDS.

POOLS.

Some eight or ten separate pools are recognized in southeastern Illinois. At the extreme north of the field, extending from Westfield to Oilfield, is the first pool brought in. It is known variously as the Oilfield, Westfield, or Parker township pool. Connected with it geographically, and extending south some six miles, is the Casey township or Martinsville pool, which in turn connects with the Johnson township pool to the south. Detached and extending to the west in Cumberland county is the Siggins pool. In Crawford, west of Robinson, is the extensive Robinson or Oblong pool. Southeast of Duncanville is a small pool taking its name from this town. Southwest of Flat Rock is the Honey Creek pool, while southeast of the same town is a new pool discovered since this map was compiled, and extending southeast of Birds. In Lawrence county there is the big Bridgeport pool, though here as in several of the others, there are different sands recognized in various parts of the area.

DEPTHS OF DRILLING.

In general the depth of the wells increases consistently from the north to the south. In the Oilfield pool the sand lies 300 to

350 feet below the surface. In the Siggins pool there are two sands found approximately 400 and 570 feet respectively in depth. In Johnson township again, there are two sands lying 470 and 610 feet below the surface. In Crawford county there seem to be a group of sands lying 900 to 1,000 feet in depth. Frequently two are developed in one hole. In Lawrence county there are three sands, the Bridgeport at 950, the Buchanon at 1,300 and the Kirkwood at 1,500. The country is very flat so that while the topography affects the depths slightly the main differences are due to structural features of the rock.

HORIZONS OF THE SANDS.

With the exception of the Kirkwood sand, which is found in the Chester formation of the Mississipian, all these sands occur in the Pennsylvania rocks. The latter have not yet been studied in Illinois in sufficient detail to permit of the series being broken up into formations which may be certainly correlated from place to place. It is known that at the base of the series is a variable thickness of Pottsville rocks, mainly conglomerates, sandstones and sandy shales. In this division the Buchanon sand occurs. The Bridgeport, Robinson and Duncanville sands, all lying at about the same horizon, belonging either in the top of the Pottsville or the base of the overlying coal measures. Owing to the imperfections of data, it is impossible as yet to make certain as to which. The remaining sands are all in the coal measures, presumably not extending far into the upper division.

In the southern pools, higher sands, corresponding at least approximately to the productive sands of the northern pools, are frequently encountered. They often show small amounts of gas but very little oil. In the northern district a few deep holes have been put down, and some at least are reliably reported to have discovered a little oil. Deep exploration has not, however, been systematic and most of the results have been unfavorable. Sufficient data are not at hand to trace northward the deeper productive sands.

FIG. 42. Structure Sections Across Illinois. (After G. H. Ashley.)

Inasmuch as the beds which are here petroliferous extend widely over Illinois, it becomes interesting and important to discriminate as far as possible the reasons for the finding of gas and oil in them here rather than elsewhere.

GENERAL STRUCTURE OF THE STATE.

The greater portion of Illinois lies within the eastern Illinois coal field, which is, broadly speaking, an extensive shallow basin. Mr. G. H. Ashley has compiled certain structure sections[1] which illustrate this fact. These are reproduced below (Fig. 42). It will be noted that from all sides the rocks dip toward a central axis running, roughly, from Shawneetown to Princeton in Bureau county. These figures, however, owing to necessary vertical exaggeration of scale, give a false effect. As a matter of fact the rocks are in the main, and to all intents and purposes, horizontal. The general dip is so slight, approximately 10 feet to the mile, that very small inequalities in thickness, and the smallest amounts of deformation, are sufficient to overcome it and produce structural terraces or even arches.

The known anticlinals in the state have been discussed by Weller.[2] The best known and probably most important, is the LaSalle anticline. This is represented in Ashley's sections *D-D* and *E-E*. In the former it is incorrectly shown as due to faulting. The major deformation at LaSalle is by folding and the difference in position of the coal beds on opposite sides of the line of deformation is complicated by unconformity.[1] Faulting, if present, is a minor phenomenon. In section *E-E* Ashley correctly indicates a probable anticlinal structure a short distance east of Charleston. The same structure was indicated by Weller,[2] and its important relation to the oil pools pointed out in advance of development in Lawrence county, and when, in fact, very little oil had yet been found in Crawford county. Geologists may therefore in this case correctly claim to have pointed out the line of development in advance of exploration.

[1] U. S. Geol. Survey, Twenty-second Ann. Rept., Pt. III., pl. XVIII.
[2] State Geol. Survey (Illinois), Bull. 6, pp. 11–13.
[1] Udden, J. A., Rept. Illinois Board World's Fair Commissioners, pp. 144–145, 1893.
[2] State Geological Survey (Illinois), Bull. 2, p. 21.

If the LaSalle anticline be projected on any good map, it will be found to run through not only the present producing pools in Illinois but the Princeton field in Indiana. The fact that in southeastern Illinois the general structure of the field is anticlinical is abundantly proven, both by study of rock outcrops and drill records. Here, then, as elsewhere, the anticlinal structure is an important condition to the accumulation of gas and oil.

DETAILED STRUCTURE IN THE DISTRICT.

It remains true that within the general limits of the LaSalle anticline there are evidently modifying conditions which determine the productivity or non-productivity of individual areas. The distribution of the gas and oil in individual pools seems to point to something more than differences in porosity of the beds, though that is undoubtedly important here as elsewhere. Along the south line of Westfield township, level lines have been run to a number of wells, and the oil sand has been correlated. This work shows the prsence of an arch four miles wide, with its crest 100 feet above the lowest explored portions of the limbs. Six miles south, a similar line of wells shows an arch 129 feet high with an explored width of two miles. Across the Siggins pool to the west a similar section shows a 68-foot arch, four miles wide. It is interesting to note that the Siggins pool shows an arch parallel to the main one, and that the barren area between the two pools corresponds to a depressed or possibly synclinical area between.

RELATIONS TO POROSITY OF ROCK.

In the very heart of the pools there are individual dry wells and even strips of apparently dry territory. Such areas probably correspond to the less porous portions of the sands. In general the " sands " are true sandstones or sandy shales, such as are everywhere common to the coal measures. The Buchanon sand is fairly coarse gritstone in which very productive wells find a supply of oil. In the Westfield pool part of the oil is found in a coal measure limestone, locally altered to dolomite.[1]

[1] Blatchley, W. S., State Geol. Survey (Illinois), Bull. 2, p. 45, 1906.

This occurrence is particularly striking in view of the fact that none of the similar coal measure limestones are known elsewhere in the state to be magnesian. Indeed these limestones are characteristically non-magnesian.

RELATIONS OF GAS AND OIL.

In general throughout the field gas occurs with oil, but not in large quantities. In Johnson township, and again near Birds, there are good oil wells with little if any gas. In Lawrence county many of the oil wells show no gas. For the field, as a whole, however, so far as present data goes, the gas and oil occur together and are crowded up under subordinate arches, within the limits of the main anticline. This is, as has been shown by Griswold,[2] the characteristic occurrence of gas and oil in wet rocks.

RELATIONS TO SALT WATER.

The oil field shows salt water at many points,[3] but the detailed relations of the gas and oil to the salt water have not yet been worked out. The beds from which the bulk of the production comes are approximately the same which yielded salt in Gallatin,[1] Saline,[2] and Perry[3] counties for many years. Water does not, however, uniformly fill the rocks of the region, as there are many dry strata, some at least of which are so coarse grained as to be abundantly fitted to serve as aquifers. Further study of the very interesting problems relating to the dryness and wetness of the rocks of the region is now being carried on.

CORRELATION OF OIL SAND.

The beds in which gas and oil occur in southeastern Illinois are of approximately the same age as certain of the more important oil sands of Ohio. In a general way the Casey sand is a homologue of the First Cow Run[4] and the Robinson sand occu-

[2] U. S. Geol. Survey, Bull. 318, p. 15.
[3] For analysis see State Geol. Survey (Illinois), Bull. 2, p. 30.
[1] Geol. Surv. Illinois (Worthen), Vol. VI., p. 213.
[2] *Ibid.*, p. 232.
[3] *Ibid.*, Vol. VI., p. 38.
[4] Bownocker, J. A., Geological Survey (Ohio), 4th ser., Bull. 1, pp. 17 et 30.

pies about the same place in the stratigraphic column as the Macksburg. The Buchanon sand thus corresponds to the Second Cow Run and the Kirkwood is roughly of the same age as the Logan group of sands. The Kirkwood may be even more closely correlated with the productive sand at Princeton, Indiana. To the west the nearest correlatives are the Mid-Continental field, where, as in Illinois, the oil occurs in the Pennsylvanian with the most productive horizons near the base.

MINOR OCCURRENCES OF GAS AND OIL.

Outside the known productive fields, and excluding for the present gas found in the drift, petroleum and natural gas have been noted at a number of points in the state. On the west from Sparta in Randolph to Litchfield, in Montgomery county, both gas and oil have been found. Recent prospecting near Sparta has shown the presence of oil in at least small quantities, and there have been similar showings at Shipman, Smithton, Hillsboro and other points. In this territory there is a pronounced erosion unconformity, both the Pottsville and Chester being cut out over parts of the territory. These beds also thin out to the north, but all the showings so far found have been in them or in the coal measures, as in Eastern Illinois. As they show the same lithology as in the latter area, and as there are anticlines or arches in western as in eastern Illinois, these showings of gas and oil are considered to be significant of probably larger quantities to be found by further prospecting.

In southern Illinois the rocks are much disturbed, faulting as well as folding being fairly widespread. For this reason the conditions are not considered equally favorable, though very little prospecting has been done in the beds most likely to be productive. There are some small showings of gas and oil in the coal measures.[1]

Outside the area covered by the Pennsylvania rocks very little is known of the possible presence of gas and oil. Neither has been found in the Mississippian below the Chester. The Devonian is not widespread in Illinois and shows no evidence of the

[1] State Geol. Surv. (Illinois), Bull. 2, pp. 73-74.

presence of either. The Niagara and the Galena-Trenton are widely present, are coarse, thick dolomites, well adapted to the storage of petroleum, are covered by suitable shales, and both show more or less oil seepage where they outcrop. In addition there is a small but attractive gas field in Pike county,[2] where the Niagara is brought near the surface by a minor anticline. In LaSalle county a small amount of gas has been obtained from the Trenton.

In the drift, gas is obtained at a number of points. Near Champaign there are individual wells which have been in use for nine years. While these wells seem, in certain cases at least, to derive their supply from decaying vegetation in the drift, the hypothesis of leakage from lower reservoirs can not be entirely excluded. This seems particularly true of the Champaign and Bureau county wells, which are located not far from the line of the LaSalle anticline. An interesting feature of these wells is the occasional finding of one which yields nitrogen instead of the ordinary combustible gas.

CONCLUSIONS.

In view of all the conditions outlined, it would seem that there may be reasonable expectation of the finding of additional supplies of gas and oil in Illinois. At present the most favorable territory seems to be in the western part of the state wherever anticlines parallel or approximately parallel to the axis of the basin may be found. In such situations they would serve to arrest oil and gas driven toward the outcrop by salt waters accumulating in the major basin. The most favorable beds are the Pottsville and Chester, and therefore the tracing of the buried outcrop of these horizons in central Illinois becomes very important. At present their northern limit is very imperfectly known. Possible reserves of gas and oil in the Niagara and Trenton are not to be overlooked, though in central and southern Illinois the depth of these formations prohibits drilling for the present at least. It is to be noted that to the north as the Chester and Pottsville thin out or disappear, the Niagara and Trenton will come within the range of practicable drilling depths.

[2] Savage, T. E., State Geol. Surv. (Illinois), Bull. 2, pp. 77–87.

Finally, attention is invited to the very minor character, from the point of view of vertical amplitude, of the arches under which the individual pools of gas and oil here occur. If these be plotted to scale it will be readily seen that their sides are not too steep to form thoroughly practicable railway grades, so one must disabuse his mind of the ordinary concept of an arch in thinking of them. In this particular they correspond to many of the arches under which oil occurs in Pennsylvania and Ohio, and also to the low arches between the basins in which zinc ore occurs in Wisconsin.[1] The whole question of the origin of such structural features may fairly be considered still open, and while on the basis of analogy one may speak of them as anticlines and synclines, their connection with horizontal thrust is far from proven. It is quite possible for the present to entertain the alternative hypothesis that they reflect original conditions of deposition or inequalities in settling during consolidation. If so, they afford comfort to those who consider the oil as having largely originated in or very near its present locus. From this point of view the finding that a certain horizon, the Trenton for example, is very commonly characterized by the presence of petroleum, is as significant of Trentonian geography and climate as the finding that the Pennsylvanian is very commonly characterized by the presence of coal. It can not be doubted that there is much in the recent development of petroleum fields to sustain such a view, and if it shall finally be proven to be valid it will be an important aid in locating and developing new petroleum fields.

[1] Bain, H. F., U. S. Geol. Survey, Bull. 294, pp. 35–43.

THE ORE DEPOSITS AT MINERAL, IDAHO.

H. W. TURNER.

The mining camp of Mineral lies along Dennitt Creek, about four miles east of the Snake River, in Washington County, Idaho. The nearest railroad point is Huntington, about twenty-five miles distant. A branch road is being built down the Snake River, and the grading for this road is completed to a point below the Mineral ferry.

Mining has been going on here intermittently for many years, all of the ores extracted being such as required smelting. Among the former smelters was one operated by Biddle and Lang. The latest smelting operations were conducted by the Ladd Metals Company, which owns several of the mines.

PRODUCT OF THE CAMP.

The values in the ore are chiefly copper and silver. The records of the smelters in operation at Mineral during 1889–1892 show shipments of copper matte containing 302,273 ounces of silver and 266,700 lbs. of copper. The Ladd Metals Company shipped ore and matte containing a total of 81,727 ounces of silver, and 261,112 lbs. of copper during 1903–1905.

Mr. Waldemar Lindgren[1] gives the production of silver previous to 1900 at about 600,000 ounces. It will be seen from this that the deposits are not extensive, but on account of the complexity of the geology, the district is an interesting and instructive one. If a thorough investigation by the Geological Survey of this or some similar district, where there is a variety of ores and rocks, could be conducted while mining is going on, it is believed that much light might be thrown on the general subject of ore deposition, for the reason that the relations and nature of the veins or deposits and the formations containing them are often more obvious than in many of the larger and more impor-

[1] 22d Annual Report of the Geological Survey.

tant districts, where frequently mechanical forcs and chemical action have been so profound as to obscure these relations.

The practical mining geologist has seldom the time and facilities to make any really thorough investigations, the object of his employment being usually to determine the quantity and value of the ore, to make suggestions for future exploitation for new ore bodies, or to find veins lost through faulting, etc.

Any thorough work involves subsequent petrographic and chemical research in well equipped laboratories, usually possessed only by geological surveys and universities. It is chiefly to these institutions that we are indebted for the main advances in the interesting subject of the origin of ore deposits.

GEOLOGY OF THE DISTRICT.

Fig. 43 represents the geology of the district.

Inasmuch as no exact mapping of the formations was attempted, and but few thin sections of rocks examined, the following account is necessarily imperfect.

Both igneous and sedimentary rocks are represented. These may be grouped as follows:

1. Porphyries having the general appearance of andesites, although more acid lavas appear to be present. These are perhaps the oldest rocks of the district, and they contain most of the important mineral deposits.

2. Coarse sandstones, showing rounded grains and fragments of igneous rocks. An inspection of this sandstone with a hand lens shows particles of feldspar, quartz, bleached mica, etc. A thin section shows that it is of a tuffaceous nature and contains abundant grains of porphyritic rocks, related to andesites and rhyolites.

These sandstones are best seen along the canyon of the North Fork of Dennitt Creek. They appear to ovrlie the andesite, and are so represented in the section (Fig. 44). The north end of the Enterprise lode (in the Jeff Davis claim) is in this material.

3. Overlying the sandstones on the west side of the canyon of the North Fork of Dennitt Creek, there is a wide belt of clay

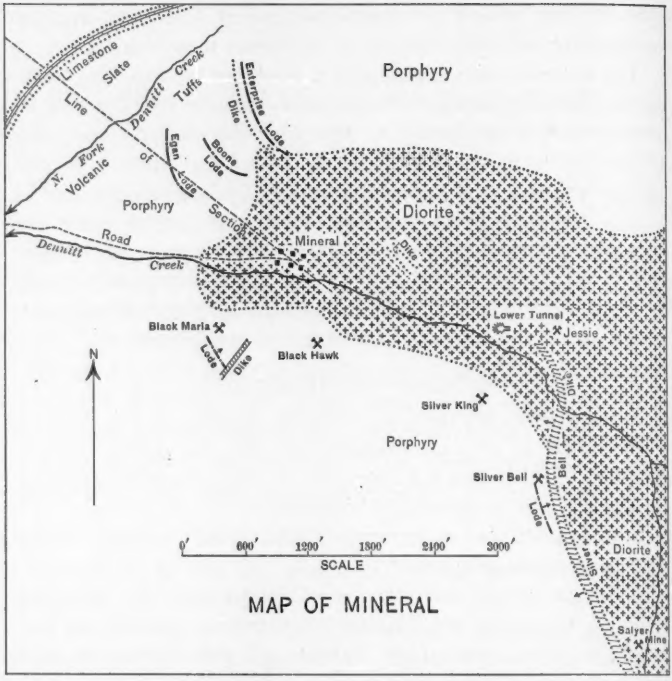


FIG. 43. Geological Map of Mineral, Idaho.

slate, with one prominent reef of limestone. This belt extends west to the Snake River. The entire sedimentary series in this vicinity dips to the northwest.

4. An intrusion of quartz-diorite forming a considerable area at Iron Mountain extends down the canyon of Dennitt Creek to the town of Mineral. This rock forms the country rock of the veins on the Jessie claim, and is found also in the lower tunnels of the Silver Bell, Black Hawk, and perhaps also the Black Maria mines. In the latter mine, the rock is so altered as to be difficult of determination.

5. It is to the period accompanying and following the intrusion of the diorite that we may assign the formation of the

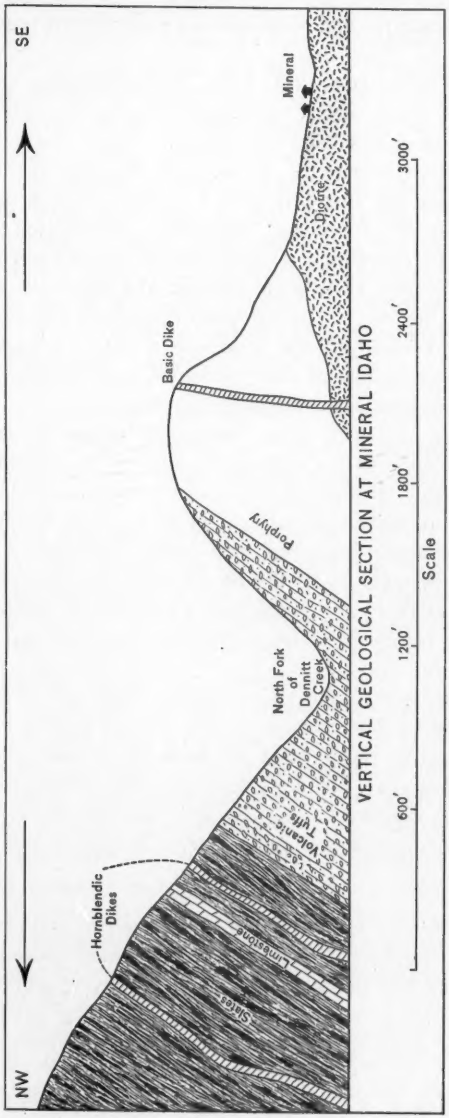

SE
NW
Mineral
Diorite
Basic Dike
Porphyry
North Fork of Dennitt Creek
Volcanic Tuffs
Limestone
Slates
Hornblendic Dikes
VERTICAL GEOLOGICAL SECTION AT MINERAL IDAHO
Scale
600'
1200'
1800'
2400'
3000'

FIG. 44.

important fractures and joint systems along which the ores were deposited.

6. At a subsequent time, there were intrusions along fractures of a basic lava resembling basalt, by which name it will be designated in this paper. These basic dikes cut all the other formations, as well as the ore-bearing seams, and represent the last product of eruptive action in the district. These dikes are not themselves mineralized except to the extent of containing a little tourmaline and pyrite. They are cut by a later system of fissures, and these are sometimes strong and definite, as in the lower tunnel of the Jessie mine. While they contain no ore, doubtless a renewed circulation of thermal waters followed their intrusion, and this may have enriched the mineral seams already formed.

There are also gray dikes containing numerous crystals of black hornblende in the clay states west of the North Fork of Dennitt Creek. No similar dikes were seen in or near the mines.

The only published account of the geology of Mineral is that by Mr. Waldemar Lindgren[1] who visited the district while investigating the geology of the Blue Mountains of Oregon. Mr. Lindgren refers to the porphyries (greenstones), and likewise places them below the slates. The whole series is provisionally referred to the Trias.

He also notes the occurrence of basalt dikes, and of the diorite, calling attention to two types of ores, one the normal type of the camp, formed by replacement of the porphyry and consisting of pyrite, chalcopyrite, blende, galena and tetrahedrite in a calcite gangue, and another in the diorite characterized by a quartz-tourmaline gangue containing pyrite, chalcopyrite and blende.

THE ORE DEPOSITS.

As indicated by Mr. Lindgren, there are two distinct types of ore deposits at Mineral, associated with distinctly different rocks:

1. Replacement deposits, mostly in porphyry, and characterized chiefly by a calcareous gangue containing pyrite, copper pyrite and tetrahedrite, with blende and sometimes a little galena.

[1] 22d Ann. Rept. U. S. Geological Survey, Pt. 6, 1902, pp. 754-756.

2. Quartz-tourmaline veins, in quartz-diorite, containing chiefly pyrite and chalcopyrite and blende. There is also more or less replacement of the diorite, by quartz, tourmaline and sulphides. Some of these veins contain gold, of which only traces are found as a rule in the calcareous type.

A third type of deposit occurs on Iron Mountain at the head of Dennitt Creek, in limestone near the diorite. This is the usual contact-metamorphic type, containing garnet and other contact minerals with chalcopyrite, etc. There is also here a considerable reef of crystalline hematite, with traces of copper carbonate. This hematite is regarded as original and not as the result of oxidation of original sulphides.

CALCAREOUS REPLACEMENT DEPOSITS.

The deposits in the porphyry are found along seams having usually a northwesterly strike, dipping mostly to the northeast at angles of 45° or more, often nearly or quite vertical, as in the Jeff Davis workings on the Enterprise lode. The deposits have clearly been formed by replacement and no evidence of fissure fillings was noted. The large part of the ore mined is from the oxidized zone, where the values are noticeably higher than in the lower sulphide zone. This is presumed to be the result of secondary enrichment, there being more or less chalcopyrite and tetrahedrite in the oxidized ore. In other words there appears here to be no marked separation of the oxidized upper zone and the zone of rich sulphides due to secondary enrichment. Both chalcopyrite and tetrahedrite have been recognized by Mr. Lindgren as primary minerals in the ores, but these minerals are thought also to have been formed by the leaching of ores and re-deposition lower down. Thus, in the south workings of the Enterprise lode on the bluff north of the town of Mineral, the ordinary ore, showing more pyrite than any other sulphide, is cut by a vein or seam made up chiefly of chalcopyrite and tetrahedrite intimately mixed.

Fig. 45 represents a section of the Silver Bell Mine where there is a westerly dipping basalt dike and easterly dipping ore-bearing seams. The best ore in the Silver Bell was found in

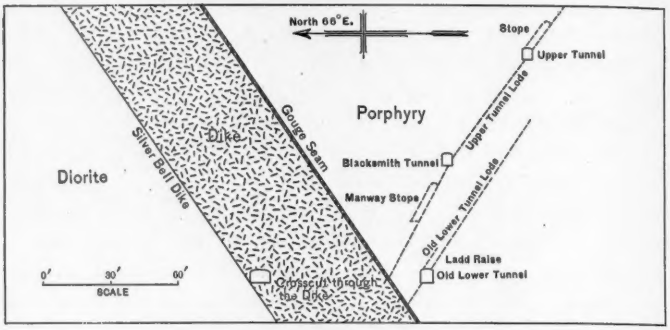


FIG. 45. Vertical Section of the Silver Bell Mine at the Ladd Raise. Looking South.

the trough thus formed between the dike and the ore seams, and this ore contained considerable tetrahedrite. The upper surface of the dike is plated with a covering of clay which is merely rotten dike-rock, but which is practically impervious to solutions. We may suppose that surface waters percolated downward along the ore seams, oxidizing the sulphides and dissolving their valuable contents, which were deposited on reaching the stagnant zone in contact with the impervious clay of the dike. At any rate the largest and best stopes of the Silver Bell were found in this trough, and the higher content of copper and silver in these stopes is known to have been due to the presence of tetrahedrite in more than normal amount, some hand specimens being chiefly made up of it. This mineral is thus possibly of secondary origin.

Gray copper is reported[1] as a secondary sulphide filling fractures in massive pyrite in the Rio Tinto mines in Spain.

In the Black Hawk mine, there was demonstrated an upper oxidized zone and a lower sulphide zone. The upper oxidized zone here again is the richer in values. The average content of the ore of this zone as deduced from 27 smelter samples was 28 ounces silver and 0.9 per cent. copper per ton, taken in 1904.

[1] J. H. L. Vogt, *Zeitschr. Prakt. Geologie*, July, 1899, pp. 249–250.

The average content of the ore in the sulphide zone was 10 ounces of silver and 1.25 per cent. copper. The oxidized zone is thus richer in silver and poorer in copper than the sulphide zone.

The best stopes in the Black Maria mine had been worked out previous to 1904, but it is known that the higher grade ore there was likewise oxidized.

QUARTZ-TOURMALINE VEINS.

The veins in the diorite are in general characterized by the presence of quartz and black fibrous tourmaline, with the sulphides of iron, copper and zinc. There are several such veins on the Jessie claim, but they are much broken and faulted making exploitation difficult. This claim is crossed by a number of basalt dikes, but in most cases the ore is not found immediately in contact with the dikes. In fact in some cases these dikes appear to have been intruded along faults which displaced the veins, and hence to be later than the veins. The quartz-tourmaline deposits are believed to have been formed by magmatic emanations from the diorite-magma rather than from the basalt-magma, although traces of tourmaline were found at one point in a minute fracture in a basalt dike.

In the lower tunnel of the Jessie mine, mineralized streaks along fissures were found at several points, the vein matter being characterized by tourmaline, pyrite, chalcopyrite and crystals of hematite.

Two strong parallel fissures with a northwesterly strike and a dip of about 60° to southwest are exposed in the main drift near the face of the tunnel, but no important mineralization took place along these fissures, one of which cuts a basalt dike, and hence is of comparatively recent origin.

In one of the upper tunnels there is a quartz-tourmaline vein, containing the sulphides of iron and copper.

Fig. 46 represents a hand-specimen from this vein. It is evident that the vein was faulted on a minute scale, the fault fractures being filled with chalcopyrite, showing its later origin.

One quartz-vein on the Jessie carries $10 per ton in gold where it is rich in zinc-blende.

In the Salyer tunnel, two dikes were crosscut, both dipping westerly. The larger of these is the same dike as that of the Silver Bell mine. Sulphides of iron, copper and zinc are found

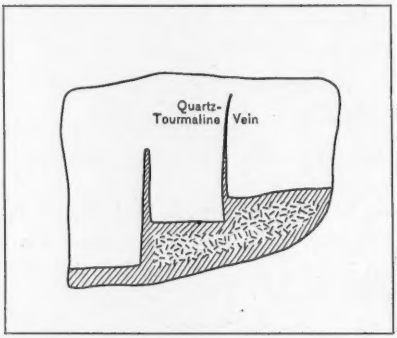


FIG. 46. Hand Specimen of a Quartz-Tourmaline Vein Showing Chalcopyrite Filling Fault Fractures.

in this tunnel with more or less black tourmaline and quartz. The country rock is diorite on the under or east side of these dikes, there being porphyry on the west side, as at the Silver Bell mine. The sulphides occur in the diorite, both between the two dikes and for a considerable distance to the east of the first or smaller dike. The width of the Silver Bell dike is here about 100′, but no mineralization was noted in the dikes themselves. These sulphides are too low in the precious metals to constitute ore.

In the new lower tunnel of the Silver Bell mine, which is in diorite, tourmaline and sulphides were likewise found, but there are no basalt dikes.

If the quartz-tourmaline veins are genetically related to the basalt dikes, similar veins should occur near the dikes in the porphyry, which is not the case.

PERIOD OF ORE DEPOSITION AND ORIGIN OF THE ORES.

The main period of fracturing of the rocks is believed to have coincided with and followed the intrusion of the quartz-diorite. The grouping of the deposits around the border of the quartz-diorite intrusion is very marked. The deposition of the ores is ascribed to thermal waters heated by the diorite-magma, and to some extent to waters of magmatic origin, especially those forming the quartz-tourmaline veins in the diorite.

If we follow the recent law laid down for us by J. E. Spurr,[1] we would ascribe all of the ore deposits at Mineral to the action of magmatic waters. In this case there is, however, the difficulty of accounting for the two types of deposit, one, in diorite, which is very silicious, and another in the immediately overlying porphyry, very calcareous. Must the idea to which miners have clung so long, of meteoric waters percolating through the crust, gradually becoming heated as depth is reached and hence becoming more active as solvents, and finally ascending and depositing their precious contents be now relegated to history? Undoubtedly all magmas contain much water, which on crystallization must be given off, as the crystallized magmas contain but little water. Undoubtedly also the igneous magmas are the original sources of metals. But is there not also a circulation of waters in the crust so ideally pictured by Van Hise, and if so, is not any heated water a solvent for metals in some form? If so what did these ascending thermal waters do with their metallic contents? Let us admit the possibility of important depositions of ore from both sources, magmatic waters, and thermal waters originally of a meteoric character. Heated water containing silica, alkalies, etc., is assuredly a solvent of metals no matter whether it came from the barysphere or the heavens above.

We may then admit that the rocks containing the veins have sometimes had an important effect on the circulating aqueous solutions, and this we apparently see in the two types of deposit at Mineral, silicious veins in silicious rocks, and calcarous deposits in porphyries which themselves contain a notable quantity of lime. (It is true that magmatic waters traversing calcareous

[1] ECONOMIC GEOLOGY, Vol. II., No. 8, December, 1907.

rocks would take up lime in solution, but if we allow the absorption of lime, why not to some extent other compounds including as well the metals?)

EFFECT OF THE BASALT DIKES ON THE DEPOSITS.

As already intimated, the dikes are regarded as later than the ore deposits. These basaltic dikes are very abundant, and a few of them are shown on the Mineral Map (Fig. 1). The most persistent of these is the Silver Bell dike, which was traced over one mile following for a considerable distance the contact of the porphyry and diorite and finally cutting through the diorite on the Jessie claim.

The fact that these dikes are found in all the important mines inclines one to ascribe the ore deposits to them, at least in part. But they cut the ore-bearing seams, as in the Black Maria and Silver Bell mines, and are not themselves mineralized. Nevertheless a renewed circulation of thermal waters presumably followed the intrusion of the dikes, and this circulation must have produced some effect on the ore deposits.

CEMENT MATERIALS OF WESTERN VIRGINIA.[1]

R. S. Bassler.

INTRODUCTION.

The recognition of cement as a most valuable structural material, and its advantages over many other building materials in cheapness and durability, has become so universal during the past ten years that, as a result, the growth of the cement industry has been equalled by that of no other non-metallic structural material. This ever-increasing demand for cement led to the establishment of new mills, and the necessity for more knowledge concerning areas of cement-making rocks. The Federal Geological Survey and the various State surveys, recognizing this necessity, have paid considerable attention to such materials, with the result that the sources of supply in a number of States are now well known. For the State of Virginia, this work was undertaken by coöperation of the U. S. Geological Survey and the Virginia Geological Survey, with Mr. J. H. Gibboney as analyst, and the writer in charge of the stratigraphy and mapping. A preliminary account of the State's cement and cement materials was published in the "Mineral Resources of Virginia," a quarto volume issued recently by the Jamestown Exposition Commission, but as this volume may not have a wide circulation outside of the State, it was thought desirable by the editor of Economic Geology, that a digest, embracing the distribution and composition of the cement rocks, be published by the writer. The work upon this subject was based upon field work during the summers of 1905 and 1906, and it is expected that a more detailed report than that mentioned above will be published as a bulletin of the Virginia Geological Survey.

The three geographical divisions of Virginia—the coastal plain,

[1] Published by permission of the Secretary of the Smithsonian Institution, and the Director of the U. S. Geological Survey.

Piedmont plateau, and Appalachian or western Virginia—are so different in the nature of their cement materials that it was deemed best to consider them separately. The present article, therefore, deals only with the limestones and shales of the larger western area. Listed in geologic order, the sources of cement materials in western Virginia are:

6. Pennington (Mississippian) shales.
5. Greenbrier (Mississippian) limestone.
4. Romney (Devonian) shales.
3. Lewistown (Helderbergian) limestone.
2. Ordovician, pure and argillaceous limestones and shales.
1. Cambrian—impure limestone and shale.

Of these, the limestones and shales of Ordovician age are the most promising on account of their abundance, widespread distribution and usually more favorable chemical composition. The Lewistown limestone and Romney shale are now used in the manufacture of Portland cement at Craigsville, in Augusta County, and the Greenbrier limestone and Pennington shale will probably become an important source of cement material in southwestern Virginia.

Of the numerous kinds of cementing materials, only those for the manufacture of cement which will set under water, or hydraulic cement, are here considered, and of the several classes of hydraulic cement, most stress is put upon the materials used in making Portland cement.

The materials for the manufacture of cement found in western Virginia are pure and argillaceous limestones, shales, slates, clays, and marls or calcareous tufa. Some of the argillaceous limestones have shown a chemical composition so close to the ideal cement rock that, judging from this fact alone, cement could be made from them directly. The purer limestones and marls are of value for mixture with the argillaceous materials, slates, clays or shales. The marls of the Appalachian Valley, however, are usually of calcareous tufa or carbonate of lime deposits from spring water. Such material has been used in the manufacture of Portland cement, but in view of the more

abundant limestones and shales, calcareous tufa can hardly be considered of economic importance.

DISTRIBUTION OF CEMENT MATERIALS.

The most important cement materials of western Virginia are found in the pure and argillaceous limestones of Cambrian and Ordovician age, and in the calcareous and argillaceous phases of the Ordovician shales. These shales and limestones have a wider distribution and are usually more accessible than such other cement rock horizons of the State as the Lewistown of Helderbergian age and the Mississippian or lower Carboniferous Greenbrier limestone. In general the entire valley of Virginia is underlain by the Cambrian and Ordovician limestones, while the shales usually outcrop along the base of the mountains bounding it. In a similar manner, many of the valleys west of the Great Valley show these limestones and shales, higher formations occurring on the separating ridges.

A study of the Cambrian and Ordovician rocks of the State has shown that western Virginia may be divided into three more or less well defined areas, in each of which the geologic sequence differs to some extent. Considering all of the State west of the Blue Ridge as western Virginia, these three areas may be designated as the northwestern, central western, and southwestern portions of Virginia. According to this somewhat arbitrary division, northwestern Virginia embraces that portion of the State north of the southern border of Rockingham county, while central western and southwestern Virginia are divided by the southern and southeastern borders of Roanoke and Craig counties.

The major portion of northwestern Virginia is included in the valley of Virginia. Almost all the cement materials of the area are confined to outcrops in the valley and to foothills of the mountains which bound it. The Blue Ridge on the east is made up of quartzites and other rocks unsuited for cement manufacture, while North and Shenandoah mountains, occupying the portion of the State west of the valley, are composed of strata of sandstones, quartzites, and shales of Silurian and Devonian age, also unsuitable for this purpose.

In a general way the geology of this portion of the State is quite simple. North of Strasburg the valley is broad, rather level, and shows two belts of limestone separated by a belt of shale, which averages four miles in width and occupies the central portion of the valley, its western edge passing just east of Strasburg and Winchester. The structure section presented below, across the valley from the Blue Ridge to Little North Mountain, about the latitude of Winchester illustrates the relation of limestone and shales in this area. Massanutten Mountain occupies the central portion of the valley south of Strasburg, extending southwest as far as the latitude of Harrisonburg.

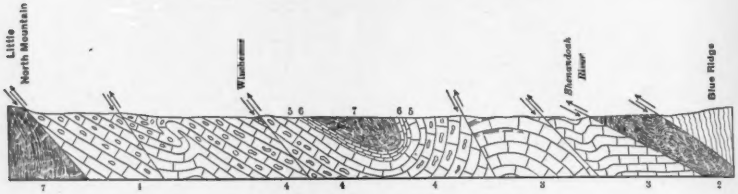


FIG. 47. Structure Section between the Blue Ridge and Little North Mountain, Virginia.

The geologic feature of this area, most important from an economic standpoint, is the great downfold of strata occupying the central part of the valley. The second structure section above illustrates the more detailed geology of this syncline just north of

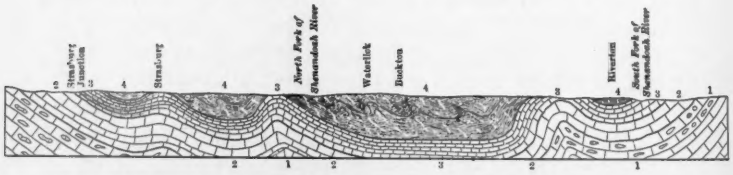


FIG. 48. Detail Structure of Syncline Shown in Fig. 47. Further North.

Massanutten Mountain. North of Strasburg, the strata enclosed in this downfold or syncline have been worn down to the general level of the valley, but south of this town, a deep sag in the syncline brings the more resistant Massanutten quartzites below

the general level of erosion of the neighboring mountains. Thus when, as a result of subsequent erosion, the Great Valley was formed, Massanutten Mountain, on account of its hard quartzite, was left as a ridge dividing the Shenandoah Valley. On account of the relation of Massanutten Mountain to this downfold, this syncline has been called the Mussanutten Mountain syncline.

Pure and argillaceous Ordovician limestones are brought to the surface along the eastern and western sides of the Massanutten Mountain syncline, hence its economic importance. Along the western side, the normal sequence of strata is usually exposed, but on the eastern side, overthrust faulting is not uncommon. This faulting is usually sufficient to cut out the limestones which are of economic importance, the dolomitic strata being thrust upon the upper Ordovician shales.

The long narrow area lying between the Massanutten Mountain syncline and the Blue Ridge is occupied by dolomitic limestones and shales which are of no importance as a source of Portland cement rock. Just west of the great syncline, pure and argillaceous limestones occur in considerable abundance, but the central portion of the western half of the Shenandoah Valley is again occupied mainly by the less valuable dolomitic limestone. The latter strata continue to the foothills of Little North Mountain, where, when faulting has occurred, they may be found resting upon the Ordovician shales or upon still higher formations.

When the structure is normal along the western edge of the Valley, essentially the same sequence of strata may be observed as farther east, with the exception that here the Trenton portion of the column contains a greater percentage of limestone than shales. In addition to the Massanutten Mountain syncline, a few smaller synclines exposing the Ordovician shales and limestones have been noted in the Valley, but these are usually of slight consequence. The most important of these minor synclines lies just west of Harrisonburg.

In central western Virginia, the more important areas of outcrop of cement materials are: (1) a narrow strip following the Massanutten Mountain syncline which terminates in this area, (2) a considerable outcrop of argillaceous limestone in the

FIG. 49. Map of Virginia, Exhibiting Outcroppings of Ordovician Limestones and Shales.

vicinity of Lexington, and (3) a rather broad band of limestones and shales just east of Little North Mountain.

From a geological standpoint, southwestern Virginia may be considered as composed of elongated, narrow, northeast-southwest blocks, in each of which, strips exposing favorable cement materials are found. Notes on the cement materials of these strips are given later in the discussion of southwest Virginia.

The more important areas of outcrop of the Ordovician limestones and shales in western Virginia are indicated on the accompanying map, figure 49.

FIG. 49. Map of Virginia, Exhibiting Outcroppings of Ordovician Limestones and Shales.

CEMENT ROCKS OF NORTHWESTERN VIRGINIA.

Nearly all of the sedimentary rocks of northwestern Virginia are of Cambrian and Ordovician age, the economic importance of the younger strata and of the area occupied by them being too small for more than general mention. Four well defined groups of Cambrian and Ordovician have been recognized in this part of the State, namely, the sandstones, quartzites, and shales of lower Cambrian age, the Shenandoah limestone belonging in part to the Cambrian and in part to the Ordovician, the Martinsburg shale of the middle and upper Ordovician, and the Massanutten sandstone hitherto regarded as Silurian. The relations and general characters of these formations are expressed in the following table:

The rocks of lower Cambrian age outcrop only along the eastern edge of the Valley and from the western slope and foothills of the Blue Ridge. The highly siliceous nature of their sediments precludes their use in the manufacture of cement.

These siliceous lower Cambrian deposits are succeeded by a great limestone series, which, on account of its general occurrence in the Shenandoah Valley, was given the name Shenandoah. This formation consists of blue, gray and dove-colored massive limestone, with interbedded slaty limestones and sandy shales. In Virginia the exact thickness has not been determined but it is probably never less than 3,500 and often more than 5,000 feet. Five distinct divisions of this limestone in central western Virginia have recently been described by Professor H. D. Campbell.

TABLE OF CAMBRIAN AND ORDOVICIAN FORMATIONS FOR NORTHWESTERN VIRGINIA.

Age.	Name.		Thickness (Feet).	Character of Rock.
Ordovician.	Massanutten sandstone.	Tuscarora quartzite.	300 ±	Coarse conglomerate and quartzite.
		Juniata formation (Lorraine).	200 ±	Sandy, reddish shales and coarser sandstone.
	Martinsburg shale.	Upper.	500 ±	Gray and buff sandy shales.
		Middle.	1000 ±	Dark gray or black fissile shale.
		Lower.	100 to 300	Calcareous drab shales in lower half; more argillaceous strata in upper part.
Ordovician.	Shenandoah group.	Chambersburg limestone.*	400	More or less pure and argillaceous limestone and calcareous shales.
		Stones River limestone.*	900 ±	Heavily bedded dolomitic limestone with purer, colored strata in upper part.
Ordovician. Saratogan. Acadian.		Natural Bridge limestone.	3500 ±	Blue gray dolomitic limestone. Upper two-thirds cherty (Knox dolomite); lower third less cherty and more shaly (Nolichucky).
		Buena Vista shale.†	600 to 900	Reddish shales with mottled blue limestone.
Georgian.		Sherwood limestone.†	1600 to 1800	White crystalline dolomite, gray magnesian limestone with occasional beds of argillaceous limestone and shale.
		Antietam sandstone.	500 ±	Firm white sandstone and sandy shales.
		Harpers shale.	1000 +	Bluish gray sandy shales.
		Weverton sandstone.	100 to 900	Massive gray and white sandstone.
		Loudoun formation.	0 to 800	Slates, shales, sandstone, limestone and conglomerates.
Algonkian?		Catoctin schist.	1000 +	Grayish-blue altered diabase with masses of eruptive granite.

[1] Portland cement rock horizons.
[2] Natural cement rock horizons.

These are, in ascending order: (1) The Sherwood limestone, (2) the Buena Vista shale, (3) the Natural Bridge limestone, (4) the Murat limestone, and (5) the Liberty Hall limestone. In northwestern Virginia, divisions corresponding to the Sherwood, Buena Vista and Natural Bridge formations are somewhat doubtfully recognized though probably continuations of the strata to the south. The Murat and Liberty Hall formations, however, are absent in this part of Virginia. Their place in the section is occupied by the partly contemporaneous pure and magnesian limestones of Stones River age, and the pure and argillaceous limestone strata designated by Mr. G. W. Stose as the Chambersburg limestone in Pennsylvania. For the present purpose, the description of these various formations given in the table is sufficient, and attention will be directed mainly to the cement rock horizons.

The lower portion of the Shenandoah group has been found useful in the manufacture of natural cement, while its upper divisions furnish the raw materials for Portland cement. The intervening formations contain too much magnesia to be of use as cement material.

The basal 1,600 to 1,800 feet of the Shenandoah group distinguished by Professor Campbell as the Sherwood limestone, consists of white crystalline dolomites with heavily bedded light blue and gray magnesian limestone and occasionally more argillaceous limestones and shales. It is in the last occurrence that the formation may prove of some value. These argillaceous limestones and shales have a composition which will allow their use particularly in the manufacture of natural cement. The principal outcrops of the Sherwood limestone are to be found along a rather narrow strip just west of the Cambrian quartzites and shales.

The succeeding formation, the Buena Vista shale, is of economic interest because limestones suitable for the manufacture of natural cement alternate with the shale, especially in the lower part. This formation is the source of the rock used by the natural cement plant near Balcony Falls, Virginia.

The heavy bedded gray and light blue limestones, distinguished

by Professor Campbell as the Natural Bridge limestone, compose one of the most prominent formations of the Appalachian Valley. The strata are almost invariably dolomitic and apparently always unsuited to the wants of the cement manufacturer.

By far the most important of the cement making rocks of Virginia are those included in the two formations next following the Natural Bridge limestone. These are limestones and shales of Middle Ordovician age. The succession of these strata in this part of Virginia is most clearly shown in a section commencing west of Strasburg Junction in Shenandoah County, and extending eastward to the vicinity of Strasburg. A generalized section, applicable to all of northwestern Virginia, is as follows:

GENERAL SECTION OF MIDDLE AND UPPER ORDOVICIAN STRATA IN NORTHWESTERN VIRGINIA.

(Martinsburg shale of Trenton, Utica, and Eden age at top.)

	Feet.
Chambersburg limestone.	
4. Gray, earthy limestone, with numerous fossils in upper part	70
3. Thin bedded and massive dove limestone holding *Nidulites* in more or less abundance	125
2. Nodular and thin bedded gray argillaceous limestone with numerous fossils in lower third	104
1. Pure limestone with cherty portions	90
Stone River limestone.	
2. Heavily bedded pure dove limestone	100
1. Alternate pure and magnesian dove limestone	500

Numerous outcrops of these limestones, favorably located with regard to transportation facilities, obtain in northwestern Virginia, but unfortunately the chemical composition of the rock is not always suited for cement making. In the following table are presented analyses of the ideal cement rock, of material used in the famous Lehigh district of Pennsylvania, and of the best materials noted in northwestern Virginia.

In the above figures, the silica iron-alumina ratio of approximately three to one, the small amount of magnesia, and the almost correct percentage of lime in the Virginia rocks are noteworthy, but, unfortunately, few places show strata so promising

ANALYSES OF PORTLAND CEMENT ROCK.

	I. Per Cent.	II. Per Cent.	III. Per Cent.	IV. Per Cent.	V. Per Cent.
SiO_2	15	22.22	14.20	18.20	16.34
Fe_2O_3, Al_2O_3	5	8.16	6.14	8.00	7.49
$CaCO_3$	75	63.45	74.30	70.00	74.14
$MgCO_3$	5	4.56	3.24	2.00	1.00
Total	100	98.39	97.88	98.20	98.97

I. Ideal Portland cement rock. II. and III. Analyses of Lehigh Valley cement rock. IV. Argillaceous limestone, Mt. Jackson, Virginia. V. Argillaceous limestone, five miles east of Woodstock, Virginia.

chemically. The composition of the more usual run of rock is expressed below.

The high percentage of lime in the upper beds of the Stones River limestone is indicated in analyses I. and II., and the possible use of this rock in raising the lime content in clayey lime-

ANALYSES OF STONES RIVER AND CHAMBERSBURG LIMESTONES IN NORTHWESTERN VIRGINIA.

	I. Per Cent.	II. Per Cent.	III. Per Cent.	IV. Per Cent.	V. Per Cent.	VI. Per Cent.
SiO_2	0.36	3.11	8.68	4.60	12.00	15.88
Fe_2O_3, Al_2O_3	0.08	0.64	1.32	0.56	2.26	0.92
$CaCO_3$	99.01	94.82	88.71	92.00	84.21	82.75
$MgCO_3$	0.45	1.53	1.34	2.79	1.13	0.44
Total	99.90	100.10	100.05	99.95	99.60	99.99

I. Pure dove limestone. Upper part of Stones River, Strasburg, Va. II. Compact black layers in upper part of Stones River, Riverton, Va. III. Dove limestone, middle part of Chambersburg limestone, Strasburg, Va. IV. Dark blue compact limestone, Chambersburg limestone, Harrisonburg, Va. V. Gray silicious limestone, upper part of Chambersburg limestone Strasburg, Va. VI. Silicious limestone, Chambersburg limestone, Riverton, Va.

stones, or for mixture with clays or shales, is obvious. The compact beds of the Chambersburg nearly always show a composition (analyses III. to VI.) in which the unusually high ratio between silica and iron-alumina is conspicuous. This same ratio prevails, although sometimes in a lesser degree, in the more argillaceous beds of the formation. It is evident, therefore, that to make a good cement mixture of these materials, care must be

exercised in the selection of materials to correct this high ratio. Clays or shales high in iron and alumina are not common and no deposits of this character were noted in the Martinsburg shale group following the Ordovician limestones.

No sharp break occurs between the argillaceous limestones and calcareous shales forming the upper part of the Chambersburg and the overlying Martinsburg shale. From an economic standpoint, no arbitrary line of separation need be given since the lowest beds of the Martinsburg shale are as highly calcareous as the topmost part of the preceding formation. In general it may be said that the lowest deposits of the Martinsburg shale are fine, calcareous to argillaceous shales, dark drab in color when fresh and yellowish when weathered. Higher up in the series, brown or black micaceous shales are encountered, while toward the top, the rocks become more siliceous. The same high ratio between silica and iron-alumina occurring in the lower limestone was noted in all samples of these strata analyzed.

CENTRAL WESTERN VIRGINIA.

The general geology of this division, although somewhat similar to that of northwestern Virginia, begins to assume the complexity of the area farther south. The great faults of southwestern Virginia are found in its southern part, while the Massanutten Mountain syncline and the structure along the western edge of the valley in the northwestern part of the state may be traced through the northern part of the division. In the intermediate zone, namely in Rockbridge County, the Ordovician limestones are so situated as a result of faulting, folding and erosion, that a considerable area is underlaid by them.

The Massanutten Mountain syncline enters the district from Rockinham County and occupies a portion of Augusta County, thus bringing the Ordovician limestones and shales to the surface as far south as Greenville. The faulting along the western edge of the valley becomes less and less in Augusta County until the structure becomes practically normal. As a result the cement limestones are more abundant in this part of the valley than northward along the same line. In the vicinity of Lexington

the argillaceous limestones are found over a considerable area, and on account of close folding seem to be of great thickness.

South of Rockbridge County the principal Ordovician outcrops follow the bases of the mountains and are thus exposed usually at some distance from railroads. Moreover, on account of the unusually steep dip of the strata, the outcrops are in long, narrow areas.

The regions of outcrop thus far noted are in the Appalachian Valley proper. West of this, namely in Alleghany, Bath and Highland counties, anticlines are found, exposing these shales and limestones as their lowest strata. Only one of these anticline areas, namely that of Hot Springs, has railroad facilities.

With a few exceptions, all of the geological divisions noted previously for northwestern Virginia may be found well developed in the central western part of the state. These exceptions are the Stones River and the Chambersburg formations. The interval between the top of the Natural Bridge limestone and the base of the Martinsburg shale is here occupied almost invariably by the Murat and the Liberty Hall limestones.

In central western Virginia, the Stones River rocks are practically absent. A few areas show a slight development, but the thickness is so slight that as a source of cement material the formation may be neglected. The succeeding Murat and Liberty Hall limestones correspond in a general way to the Chambersburg limestone of the more northern parts of the valley, although lithologically no trouble need be encountered in distinguishing these different divisions.

The heavy, locally cherty magnesian beds of the Natural Bridge limestone are usually followed by a massive gray, coarsely crystalline pure limestone to which Professor Campbell has applied the name Murat, from its occurrence along Buffalo Creek, at Murat, Virginia. The limestone as a whole runs very high in calcium carbonate, and for this reason, it is the source of the lime burned at several points in central-western Virginia. About 125 feet of the Murat limestone are exposed at its type locality but frequently the thickness is not so great.

Succeeding the comparatively pure Murat limestone is a suc-

cession of more siliceous and argillaceous strata possibly 1,000 feet in thickness. This is the Liberty Hall limestone which was so named by Professor Campbell because of the old historic ruin near Lexington constructed on and of this rock. Fine-grained dark blue strata make up the lower third of the formation. Darker, more argillaceous limestone occurs in the middle third, changing into calcareous shale in the topmost division. After long exposure to the weather, the middle and upper divisions appear shaly at the surface. Some of the strata of this formation approach the typical Lehigh Valley cement rock more closely both in physical and chemical characters than any other of the cement rocks in western Virginia. These particular rocks have an obscure conchoidal fracture and a silky luster. They range through a thickness of about 250 feet. Many of the layers show a chemical composition closely approaching that of the ideal cement rock, while in others again the same high ratio between silica and iron-alumina, noted previously, is presenet. This latter composition is shown in analysis III. of the following table, while numbers II. and IV. to VI. are of materials having a very favorable composition. The purity of the Murat limestone is brought out by analysis I.

ANALYSES OF LIMESTONES FROM LEXINGTON, VA.
(Charles Catlett, analysis.)

	I. Per Cent.	II. Per Cent.	III. Per Cent.	IV. Per Cent.	V. Per Cent.	VI. Per Cent.
SiO_2	0.73	9.31	11.86	12.92	17.42	22.60
Fe_2O_3, Al_2O_3	.79	3.47	1.76	3.88	4.70	7.60
CaO	53.71	46.30	46.64	45.14	42.44	36.72
MgO	.83	.88	.74	1.37	1.68	1.69
CO_2			38.32	37.20	35.62	32.52

I. Pure, coarsely crystalline, gray, Murat limestone. II.–VI. Compact dark argillaceous limestone of Liberty Hall formation.

The Murat limestone is extensively quarried at Eagle Mountain where the formation is well developed. Analyses of the purer rock and of the calcareous lower beds of the Liberty Hall limestone are presented in numbers I. and II. of the following table. The comparatively high silica content of the latter formation in other parts of central western Virginia is indicated in analyses III. and IV.

ANALYSES OF MURAT AND LIBERTY HALL LIMESTONES IN CENTRAL-WESTERN VIRGINIA.

	I. Per Cent.	II. Per Cent.	III. Per Cent.	IV. Per Cent.
SiO_2	1.80	7.10	9.38	19.48
Fe_2O_3, Al_2O_3	0.22	0.92	1.02	2.74
CaO	54.50	51.10	49.56	42.16
$CaCO_3$	97.32	91.25	88.50	75.29
MgO	0.07	0.46	.57	.81
$MgCO_3$	0.15	0.96	1.21	1.70
Total	99.49	100.23	100.11	99.21

I. Murat limestone, Eagle Mountain, Virginia. II. Compact black limestone, base of Liberty Hall, Eagle Mountain, Virginia. III. Fine grained dark blue limestone (Liberty Hall) Staunton, Virginia. IV. Shaly limestone (Liberty Hall), Mt Sidney, Virginia.

CEMENT ROCKS OF SOUTHWESTERN VIRGINIA.

In the discussion of northwestern and central western Virginia, the writer has indicated no great differences in the stratigraphic succession or the lithology of the Ordovician strata in various parts of the valley. In southwestern Virginia, however, a new factor in the study of these same strata is introduced. Ordinarily rocks deposited synchronously in comparatively small areas show no great differences either in lithological aspect or in their fossil contents. In the division of the state now to be discussed, the Ordovician strata particularly, differ in various areas in both of these respects. For example, the eastern portion of the great Valley shows a development of Ordovician limestones and shales totally different from that found in the westernmost part of the state. In the study of the various sections, these differences in strata of apparently the same age were encountered in traverses made across the valley and ridges to the west, while little difficulty was experienced in correlating the rocks in directions paralleling the length of the valley.

When compared with the two divisions discussed previously, the geology of southwestern Virginia is complicated by great folds and overthrust faults. The region is traversed in a northeast-southwest direction by at least seven major faults and a number of minor breaks. The easternmost of these major

faults passes along the base of the Holston and Iron mountains, where a sandstone of Lower Cambrian age is faulted against the dolomitic limestones. Sandstone, shale, and impure limestone outcrop east of this fault, but on account of their unsuitable chemical composition are not considered here. See figure 50.

The six major faults west of this eastern break have been described and named by Professors Lesley and Stevenson. These are, in order going westward: (1) The Walker Mountain, (2) Saltville, (3) Copper Creek, (4) Hunter Valley, (5) Wallen Valley and (6) Poor Valley faults. These seven major faults divide southwestern Virginia into six rather narrow areas, in each of which a belt of Ordovician limestones and shales is usually exposed. The general distribution of the cement-making materials in these areas is indicated on the maps of Virginia, with the relation of these faults to each other and to the topography, as well as the arrangement of the strata in each of the areas is shown in the accompanying structure section.

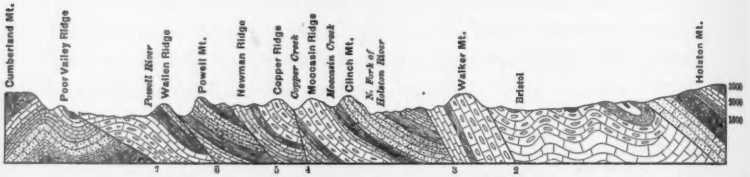


FIG. 50. Structure Section across "The Valley" in Southwestern Virginia.

The study of numerous sections including the Ordovician rocks in this part of the state emphasized the fact, as mentioned before, that similar successions of these strata are at present exposed in long narrow areas bounded by the major faults. The differences of sedimentation in these various areas may perhaps most readily be shown by an outline of the stratigraphic succession in each. In both cases the well known Knox dolomite serves as a basal datum line and the identification of the various formations rests upon their fossil contents as well as their lithologic characters. The formation names employed are those used by Mr. M. A. Campbell in the Bristol, Estillville,

Pocahontas and Tazewell folios, of the U. S. Geological Survey.

In the easternmost area, namely the region between the Blue Ridge and the Walker Mountain fault, the following succession of Ordovician rocks may be observed:

	Feet.
3. Thin bedded sandstones and sandy shales (Tellico)	300 +
2. Blue to black calcareous and sandy shales (Athens)	1,200
1. Knox dolomite	3,500 ±

Locally, a thin, somewhat magnesian, blue limestone, mapped as the Chickamauga limestone in the Bristol and Estillville folios of southwestern Virginia, occurs between the Knox and the Athens.

Beds of marble belonging to the Halston immediately follow the Knox dolomite in the Clinch Mountain area, namely the region between the Saltville and Copper Creek faults. Here, with the exception that the Chickamauga limestone and Athens shale are wanting, the section, as shown below, is essentially the same as the preceding one:

	Feet.
6. Heavily bedded white quartzite and sandstone (Clinch)	300
5. Red sandy shales and thin bedded sandstone (Bays)	300
4. Yellow and dark colored shales with thin bedded limestone at the base (Sevier)	1,500
3. Red calcareous shales and impure red limestone (Moccasin)	500
2. Marble at base followed by thin bedded limestones and shales (Holston)	1,000
1. Knox dolomite	2,100 +

The strip bounded by the Copper Creek and Hunter Valley faults, here called the Copper Creek area, contains the Knox dolomite, the Moccasin, Sevier, Bays, and Clinch formations, but in place of the marbles and thin bedded limestones of the Holston, heavily bedded, gray and dark blue limestone is found. The difference between this and the Holston marble may be seen in cuts along the Virginia and Southwestern Railroad, near Speer Ferry and Clinchport.

The westernmost and most different sequence of the Ordovician in Virginia is found in the valley of Powell River, where the succession of the rocks is almost exactly the same as that obtaining in southwestern Ohio, central Kentucky, and central

Tennessee. In Virginia, these rocks are known to occur throughout the Powell River valley eastward to the Wallen Valley fault, and in all probability the narrow strip between this fault and that of Hunter Valley is also occupied by them. The formational names employed below for the rocks in this area are those used in the folios of the U. S. Geological Survey.

	Feet.
Clinch.	
10. Heavy bedded white quartzite or sandstone	10+
Bays.	
9. Red and yellow limestones and shales	250
Sevier.	
8. Yellow arenaceous shales and limestones	300
7. Olive and yellow shales	300
Chicamauga.	
6. Thin bedded blue limestones and blue or yellow shales	50
5. Dark blue crystalline limestone	300
4. Yellow and olive shales	300
3. Thin bedded dove limeestones and yellow shales	350+
2. Massive dove limestone	300+
Knox.	
1. Massive dolomite.	

From the foregoing description it is evident that southwestern Virginia has a great variety of cement material. It is of course impossible to note these in any detail in the present article, so the composition of the rock only in areas having railroad facilities is mentioned below. These particular areas are (1) the vicinity of Bristol where the Chickamauga limestone and Athens shale form the cement materials, (2) the Clinch Mountain exposures, and (3) the Powell Valley region of southwestern Virginia.

The relatively high lime content of the Chickamauga limestone suggests its possible use for mixture with the associated Athens shale. This shale, however, often shows the same high ratio between silica and iron-alumina noted elsewhere in Virginia, so that very careful mixing of material would be necessary.

The limestones and shales making up the Holston marble and associated strata present a variety of cement materials necessary to make a proper mixture. The marbles, which are often pure calcium carbonate, are confined mainly to the lower part of the

ANALYSES OF CHICKAMAUGA, ATHENS, AND HOLSTON FORMATIONS.

	I. Per Cent.	II. Per Cent.	III. Per Cent.	IV. Per Cent.	V. Per Cent.	VI. Per Cent.
SiO_2	4.60	19.49	11.24	8.42	0.86	33.80
Organic matter	—	1.28	.60	—	—	—
Fe_2O_3, Al_2O_3	.24	1.28	.96	3.66	1.10	4.36
CaO	51.90	42.20	48.62	47.12	55.00	35.14
$CaCO_3$	92.68	75.36	86.82	84.14	98.21	59.18
MgO	1.06	1.16	Trace	0.67	0.08	0.66
$MgCO_3$	2.32	2.45	Trace	1.41	0.17	1.38
Total	99.84	99.86	99.62	97.63	100.34	98.72

I. Slightly magnesian Chickamauga limestone, four miles south of Saltville, Va. II. Calcareous Athens shale, two miles south of Abingdon, Va. III. Shaly limestone in Athens shale, three miles eact of Bristol, Va. IV. Blue argillaceous limestone (Holston), Gate City, Va. V. Coarsely crystalline marble (base of Holston), Speer Ferry, Va. VI. Drab shales (Holston), Speer Ferry, Va.

formation, the upper part usually being argillaceous limestones and calcareous shales. Analyses IV, V. and VI show the range in composition and variety of materials in the Holston. The best and most accessible outcrops of these strata are at the base of Clinch Mountain, between Gate City and Speer Ferry. The Virginia and Southwestern Railroad closely follows this line of outcrop. In the Powell River Valley of the extreme southwestern part of the State the Louisville and Nshville railroad closely approaches and at one point crosses the westernmost band of outcrop.

Such a variety of cement materials is found in these Ordovician limestones and shales that no difficulty would probably be experienced in selecting materials chemically suited for a proper mixture.

POST-ORDOVICIAN CEMENT MATERIALS.

As noted before, the Ordovician limestones and shales are of prime importance in western Virginia from a cement standpoint, on account of their abundance and usually more favorable location. Two other limestone formations, suited chemically for cement manufacture, exist here, and associated with each is a shale. These are the Lewistown limestone and Romney shale, and the Greenbrier or Newman limestone and Pennington shale

respectively. However, their areas of outcrop are comparatively few, are of little extent, and are generally situated so far from transportation facilities that, with the exception of a few localities, the rock now has little economic value.

At present the most important region of Lewistown limestone is in Augusta County, commencing at Pond Gap and continuing for some miles southwest. Transportation here is by the Chesapeake and Ohio Railroad, and this favorable conjunction of railroad facilities and good cement rock has been taken advantage of in the establishment of a Portland Cement factory at Craigsville. This plant, the property of the Virginia Portland Cement Company, is of note in that it is the only well established Portland cement manufactory in the state.

The Greenbrier limestone is best developed in West Virginia, but a detailed section may be seen along the Norfolk and Western Railroad near Lurich in Giles County. Indeed this, and exposures along the Virginia and Southwestern Railroad in southwestern Virginia, are the only localities having transportation facilities.

NATURAL CEMENT.

Under ordinary circumstances the value of natural cement is too small to allow it to be shipped any distance with profit. Therefore, the manufacturer must have a home market and little competition. The raw material is an argillaceous limestone carrying from 13 to 35 per cent. of clayey material, of which about 10 to 22 per cent. is silica, while alumina and iron oxide together may vary from 4 to 16 per cent. Unlike Portland cement rock, the percentage of magnesium carbonate may run high, the reason for this being, that in natural cements the magnesia and lime are regarded as interchangeable. The hydraulic properties do not depend upon the percentage of lime but upon the clayey materials, which threfore are the important factors to consider in the rock analysis. Limestones having a composition within the limits just indicated are more or less abundant at several horizons in western Virginia, but probably the only one which will meet all the requirements and prove of

economic importance is the argillaceous magnesian limestone of the lower part of the Shenandoah group. This rock, although often very similar in lithologic characters to the dolomitic limestone found higher in the Shenandoah, can be recognized as containing argillaceous matter by the clayey odor given forth when breathed upon.

Limestones suitable for the manufacture of natural cement occur in southwestern Virginia, particularly along the eastern half of the Appalachian Valley. Geologically, these succeed the siliceous deposits of lower Cambrian age and form the base of the great Shenandoah limestone group.

CEMENT INDUSTRY IN VIRGINIA.

Although the cement industry may be said to be in its infancy in western Virginia, yet the manufacture of this important economic product has been carried on for many years at one locality, and for a less time at another. Natural cement has been burned near Balcony Falls, Rockbridge County, for over half a century. The demand for a cheap and trustworthy cement for use in the construction of masonry locks and walls on the James River Canal, led to the discovery of the hydraulic properties of the rock used at this plant. Since that time a natural cement has been manufactured at this locality almost continuously, the James River Cement Company operating the plant at the present time. The rock used is a steel blue, argillaceous limestone of lower Cambrian age, with an average thickness of twelve feet. For a description and history of this cement plant, the reader is referred to an anonymous article published in the *Engineer*, September 29, 1899.

But a single plant for the manufacture of Portland cement is in operation in Virginia, namely, that of the Virginia Portland Cement Company, at Craigsville, Augusta County. The materials used here in the manufacture of the Old Dominion cement are Lewistown limestone and shale. The principal limestone quarry is located a mile and one eighth from the plant, and the shale quarry three quarters of a mile. The present output of

this plant is between 1,800 and 1,900 barrels per day, but construction work is under way to increase the capacity to 3,000 barrels per day. As the mill is located so far away from any city, it was necessary for the company to provide homes for its employees. In addition, the company runs a commissary store, village water works, employs a physician and maintains a hospital. In this way a town maintained by the company itself has grown up about the plant.

A NEW DISCOVERY OF PERIDOTITE IN ARKANSAS.

A. H. PURDUE.

A small area of igneous rock, which was eventually determined as peridotite, located about two and a half miles southeast of Murfreesboro, near the mouth of Prairie Creek, Pike County,

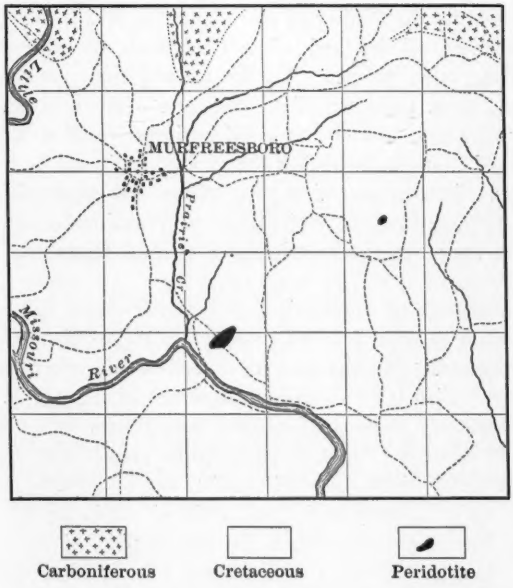


FIG. 51. Map of T. 8s, R. 25w, showing the distribution of the known peridotite.

Arkansas, has been known to geologists since 1842. A history of the observations upon this area, together with the geological relations and nature of the peridotite, has been published by Drs.

J. C. Branner and R. N. Brackett,[1] and reproduced[2] by the late Dr. J. Francis Williams. That the possible economic value of these rocks did not pass unnoticed by the authors cited, is shown from the following paragraph:

"Inasmuch as it has been suggested that the South African diamonds may have been generated by the metamorphism of the carbon in the carbonaceous shales penetrated by peridotite, it should be added that no such phenomenon is suggested by observations at this locality upon these rocks."[3]

On August 1, 1906, the vague suspicion indicated in the foregoing paragraph of the occurrence of diamonds in this rock, was verified by the finding of two stones by Mr. J. W. Huddleson, the owner of the land. Mr. Huddleson subsequently sold the land to other parties. To the present time (May, 1908) somewhat more than 200 diamonds have been reported. Fortunately, the land passed into good business hands so that sane methods of thoroughly testing the ground will soon be put into operation. In the meantime the place has been visited by Messrs. George F. Kunz and Henry S. Washington, who have published their observations in a paper on "Diamonds in Arkansas."[4]

The discovery of diamonds in the above mentioned area of igneous rock at once aroused prospectors to search for similar areas elsewhere. To the present time, but one other has been discovered. This is located near the center of sec. 14, T. 8s, R. 25w., three miles from Murfreesboro, and a little more than two and a half miles northeast of the original area. The discovery was made by M. N. Burgess, of Murfreesboro. The accompanying map (Fig. 2) prepared from a sketch made by the writer while on the grounds, represents the topographic relations of the igneous outcrop. The top of the ridge is covered to the depth of ten to twelve feet with "plateau gravel" (Lafayette formation) cemented into a conglomerate. Through the weathering

[1] "The peridotite of Pike County, Arkansas," *Amer. Jour. Sci.*, Series 3, Vol. XXXVIII., 1889, p. 50.

[2] Geol. Surv. of Ark., Vol. II., 1890, p. 378.

[3] Geol. Surv. of Ark., Vol. II., 1890, p. 389.

[4] *Trans. Amer. Inst. Min. Eng.*, Bi-Monthly Bull. No. 20, pp. 187–194.

of the hillsides, this gravel has gradually shifted downward until it has covered a considerable portion of the slopes. The peridotite is of the type that weathers rapidly, and consequently shows on the surface only in a few fragments the size of one's fist and smaller. This fact, together with the somewhat rough topography and the heavy timber covering the region has prevented its earlier discovery.

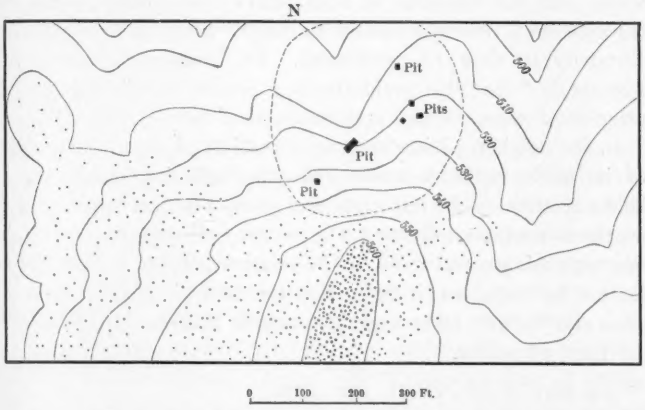


FIG. 52. Topographic map of the N½, NE¼, SW¼, sec. 14, T. 8s, R. 25w. Stippled area is plateau gravel. Pits show prospect holes in peridotite. Dotted line shows apparent border of the peridotite.

Because of the decomposed state of the peridotite and the encroachment upon it of gravel and soil from the slopes above, the determination of its exact extent will necessitate considerable exploiting. At present, the area that can confidently be considered as covered by this rock is between two and a half and three acres. The actual area probably is greater than this.

The soil resulting from the disintegration of this peridotite, like that of the older known area, is green, brown and yellow, according to the stages of oxidation. No drilling has been done to determine the depth of the soil. Comparatively solid fragments of the rock thrown out on the surface in the small amount of excavating that has been done, go to pieces after a few days

exposure. A macroscopic examination of this rock and specimens from the original igneous area reveals no difference between them.

While the writer saw no exposure of the rock in the immediate locality beneath the plateau gravel, this subjacent rock is almost certainly of Cretaceous age, as will be seen by reference to Fig. 1. The apparent identity of the rock of the two igneous areas, and the fact that in both places the igneous rocks cut through the Cretaceous, leaves sacrcely a doubt as to exact synchroneity in time of formation. Dr. Branner advances the hypothesis "that this peridotite is a simple injection that took place about the close of Cretaceous times."[1]

In the original peridotite area, a portion of the rock, because of its ability to withstand weathering agencies, stands up as knobs from 60 to 80 feet high, and about 800 feet apart, with a northeast-southwest trend. The recently discovered area is in line with this general trend. The relations, so far as they can at present be made out, indicate that the latter is also an injected mass and the two taken together suggest that the injection took the form of a dike.

[1] Geol. Surv. of Ark., Vol. II., 1890, p. 390.

DISCUSSION

A THEORY OF ORE DEPOSITION.

DISCUSSION OF A REVIEW BY F. L. RANSOME, OF PAPER BY J. E. SPURR.

Sir: The caustic criticism of Mr. Spurr's paper by Dr. Ransome, which appeared in the last number of ECONOMIC GEOLOGY, is an extreme illustration of the process whereby critical reviews generally fail in American science. No wonder that Mr. Owen Wister and Mr. Carl Snyder are pessimistic about our progress if such unsympathetic communications as this one are permitted to represent the judicial attitude of men of science in the United States, when one of their number in good faith, with modest premises and earnest purpose, has written a short suggestive article for the scientific press. Dr. Ransome's plan of attack is particularly remarkable, in that he opens his letter by practically saying that he intends to be personal, and that this is his duty as an editor. He certainly lives up to the intention so expressed when he follows this with such phrases as "dubious treatment of important subjects," and accuses Mr. Spurr of violating the "traditions of science," of self-seeking, of "presentation essentially unscientific," and of leading young investigators astray. One would suppose that *because* Mr. Ransome is an editor he would make a special effort to be gentle and courteous in his treatment of a contributor, particularly as the editorial board is responsible for what the magazine has published. Would Dana or Asa Gray or Pasteur ever have written such unappreciative and unkind comments on the work of a colleague?

It is not the intention of the present writer to enter upon another criticism, either favorable or unfavorable, of Mr. Spurr's paper. He was interested in what Mr. Spurr had to say, and

read the paper through with more satisfaction than he generally gleans from scientific articles, for the reason that the writer did not burden his production with either a great load of facts or a pedantic cargo of footnote references. The title would have been bettered if the author had called it "Some Generalizations Concerning Ores." The absence of reference to abyssal assimilation and to a possible ultra-basic primary magma was noticeable, but Mr. Spurr had disclaimed eclecticism in his opening paragraphs, stating that the working hypothesis advanced was that under which he himself labored, that it was drawn from field experience, and that he outlined it for the readers of ECONOMIC GEOLOGY for what it might be worth. He expressly stated that he was writing in the field without access to a geological library, and recognized the shortcomings of his production which would result from such surroundings. Inaccuracies and omissions were consequently more conspicuous than they would otherwise have been, particularly as the field covered was large and distinctly polemical. Nevertheless the editor rightly accepted the article and published it.

That the paper would invite criticism was inevitable and desirable, and the author would be the first to welcome it. It is improbable that Mr. Spurr is ignorant of the work of de Launay, and Dr. Ransome's incessant ringing in of authors to show that in certain details Mr. Spurr is "behind the times" is as unnecessary as it is unsympathetic with the larger purpose which Mr. Spurr had in view. That larger purpose was to set forth an intelligible conception or account of how all ore deposits may have come into being, showing the relation of all the parts to the whole, as they present themselves to the imagination of a certain man of large field experience. All induction is based on imagination and the great doctrines of science have had their origins in just such statements of relationship, usually, as in this case, scoffed at in the beginning as being erroneous or in no way original. It would indeed be difficult for any author to invent a theory of ore-deposits which would be original, in view of the wide diversity of views which have been published in re-

cent years, covering nearly every possibility and involving all the processes of geology, profound and superficial.

Dr. Ransome, in condemning, not only disregards the first condition which, by permission, makes the paper suggestive rather than rigorous—*viz.*, the absence of reference to published writings—but he further demolishes the poor author, writing in a distant mining camp, by picking his words to pieces. Very properly, the critic recognizes that the author's main thesis is that ore-bodies, veins and igneous rocks are genetically modifications of a primary magma or deep seated solution. Incidentally, Mr. Spurr states that veins and dikes are essentially identical. This view, to anyone who has pondered in the field the relations of quartz veins, pegmatites, and granitic quartz, is at once both bold and suggestive. Dr. Ransome is shocked at the mention of veins as intrusive and writes "there is no doubt at all in the minds of most geologists that there is an essential difference between the typical or usual vein and the typical or usual dike." It is noteworthy that he does not say what this difference is: does he know? There is certainly great doubt in the mind of the present reviewer. Dr. Ransome further quarrels with Mr. Spurr's use of the word *theory* and insists on *hypothesis*: the editors of the Century Dictionary evidently displease him, for they quote Reid, Channing, Whewell and Tennyson as using *theory* just as it is used by Mr. Spurr, as a more modest word than hypothesis, but essentially synonymous.

There is always a place in scientific reading for articles more or less ephemeral, which represent the synthetic thought of experienced men and the criticism of their contemporaries. The weekly or monthly reviews are suitable places for publishing such material. If twenty other men, with suitable apology by way of prologue, would do just as Mr. Spurr has done, they would themselves he helped by the comments evoked and they would help others, as in conversation, by suggestion. Such papers are widely read and the errors in them do no harm for they rise at once to the surface. Kindly, constructive criticism, whether favorable or adverse, can do nothing but good, and will always be taken in good part. The very comment which Mr.

Spurr has excited makes for scientific progress. The spirit of sarcastic hypercriticism, intolerance and quibbling over words is destructive of all patience and all good feeling among scientific men, and this spirit is all too rife at present in the United States Geological Survey. It is to be feared that the Washington atmosphere of dogmatic officialism has somewhat affected Dr. Ransome's discussion.

T. A. JAGGAR, JR.

THE OXIDATION OF PYRITE.

DISCUSSION OF PAPER BY A. N. WINCHELL.

Sir: Last June I noted Mr. Winchell's paper on pyrite and before realizing it was to be discussed or questioned, I suspected that the conditions under which the experiments were performed would seldom be approached in nature. The comparison of conditions of experiment with nature has not yet been made, and would be difficult on account of the endless variety in nature. Mr. Read's discussion apparently questions some of the assumptions regarding the analogy of experiment and nature, but gives no more evidence either way than Mr. Winchell gave in the first instance.

The problem, as stated by Mr. Winchell, is " to determine the conditions under which the process of oxidation may occur, and the approximate rate at which it proceeds." He found that under the conditions he selected there was some oxidation, and he measured the rate. But it occurred to the writer that exprirments might be performed very simply, and at the same time with all necessary care, to test other conditions and other pyrite. So the following results are offered, not as a correction or criticism, but as a different case.

Near the surface of the ground, where oxidation seems to be rapid, the conditions may not be those of constant circulation of water, but a mineral will be alternately wet and dry. It was thought possible that oxidation would be more rapid if this natural condition could be imitated. Glass crystallizing dishes were

weighed and a known amount of pyrite spread over the bottom of each dish, exposing it well to air. These were barely covered with distilled water as often as they became dry. The exposure lasted just twelve months, but the wetting was neglected for three months of the summer field season. As the air of the building was not always very pure, the dishes were kept outside as much as the weather permitted, and in the shade. They were covered with a large glass and a blank was carried beside them to correct for any dust accumulation.

The samples used were as follows: (1) Marcasite, well crystallized in tufts, Cuba, Wis.; (2) Pyrite, fine cube, Jersey Shore, N. J.; (3) Pyrite, pyritohedron, Elba. Each sample was ground to pass a 20-mesh sieve and was caught on an 80-mesh sieve. The powder was washed in hot diluted hydrochloric acid till the reaction for iron could no longer be seen, and then rapidly washed in water, alcohol and ether and dried. Each was very pure FeS_2. The part not weathered was kept well stoppered and dry. After the year of treatment, fresh samples were weighed from the original and the difference between the dry and weathered samples is evident from the table below. The samples all gained considerably in weight after ex-

No.	Grams Used.	Iron Soluble in HCl.		Sulphur Soluble in HCl.	
		In Original.	In Weathered.	In Original.	In Weathered.
		Per Cent.	Per Cent.	Per Cent.	Per Cent.
Blank.	0	0.00	0.001	0.00	0.001
1	15	0.005	0.021	0.003	0.024
2	5	0.006	0.032	0.001	0.033
3	15	0.002	0.010	0.002	0.012

The pyrite apparently oxidized is as follows:

No. 1 ..... 0.032 per cent.
No. 2 ..... 0.057 per cent.
No. 3 ..... 0.015 per cent.

Mr. Winchell's more elaborate and continuous method gave 0.067 per cent. which is not far from one of the simpler tests here reported. The results, however, do not lead to much further clarification of the problem, indicating a variation not yet accounted for. The samples were treated identically, as far

as possible, but results vary with the material. There is still no evidence of rapid oxidation, as all results are slower than that of Mr. Winchell. The smaller amount of material should not effect the value of the result.

FRANK F. GROUT.

THE LOCALIZATION OF VALUES AND THE OCCURRENCE OF SHOOTS IN METALLIFEROUS DEPOSITS.

Sir: I have read with much interest the opening remarks of J. D. Irving, also the article by Mr. Sales, recently issued in the discussion which has been inaugurated in ECONOMIC GEOLOGY.

I believe that the result of bringing together a series of articles by different observers on this subject will prove of great value, not only to those interested in the science of ore deposits, but will be of intrinsic value to those engaged in exploiting mineral occurrences.

The distinction made by Irving between "Shoots of Occurrence" and "Shoots of Variation" appeals to me as the solution of a long-felt want in classification which I have personally felt the need of in describing cases of secondary enrichment in primary ore shoots.

The bringing together of carefully observed data in regard to the form and distribution of ore bodies can not fail to prove helpful to those engaged in field work.

It is to be regretted that a more definite nomenclature with regard to the shape of such ore bodies than that at present used is not available, as the vernacular terms, such as "pockets," "nests," etc., afford no idea whatever of shape, when sought to be applied for correlation purposes.

With regard to the phrase "Pay Shoots" and the general adoption of this term, I think that while it is a very useful one to express local profitable conditions—from a purely commercial point of view—yet it can hardly be applied universally to indicate mere differences between all masses of ore, which carry a higher content of ore mineral than the adjacent material and the low grade material by which they may be surrounded. The

subject you have now brought forward for discussion on the localization of ore shoots is one of the greatest interest to students of Economic Geology. My own experience in Australia and Europe, and lately in the United States, confirms the necessity for a better understanding among mining geologists and engineers as to the nomenclature to be used when describing the essential characteristics, modes of occurrence, shape and origin of ore shoots.

I hope later to present to the readers of ECONOMIC GEOLOGY "a few facts of observation" in an article now in preparation for the Journal.

JAMES STIRLING.

NOTE ON THE OCCURRENCE OF GRAPHITE SCHIST IN TUXEDO PARK, N. Y.

Sir: The occurrence of graphite in the rocks of the Highlands in New York and New Jersey has been known for a long time. Numerous references to the mineral are encountered in the descriptions of the gneisses and limestones of the district. These, however, are all general statements, which relate the fact that the gneisses and other rocks of the Highland region sometimes contain graphite in abundance. The most detailed account of the manner of occurrence of the mineral in the gneissic rocks is found in a report by F. L. Nason,[1] in which the graphite is described as occuring in a graphite gneiss, which forms narrow layers in the country rocks, sometimes extending in straight lines for a score or more miles. Nothing more definite than this with reference to the existence of graphite in the siliceous rocks has been found in the literature of the New Jersey Highlands or the adjacent district in New York.

Observations in the New York Highlands west of the Hudson River and in the New Jersey Highlands indicate that the graphite exists in four conditions:

1. As a component of the Franklin limestone, which is a white crystalline pre-Cambrian rock.

[1] Annual report of the State Geologist for 1889. Geol. Survey of N. J., pp. 64–65.

2. In bands of garnetiferous mica gneisses that may, in some instances, represent altered fragmental rocks, but which, in other cases, are certainly mashed pegmatites.

3. In coarse-grained granite dykes or pegmatites.

4. In fine-grained quartzitic micaceous schists, especially where these are associated with pegmatites.

The last named method of occurrence is the most important, since in several places the graphite content of the schist is so large that attempts have been made to mine the rock as a source of the mineral. Concentrating works were erected at Bloomingdale, Highbridge and near Brookside in New Jersey, for this purpose, but in no case was the venture a financial success.

The following notes describe the method of occurrence of the graphitic schist in Tuxedo Park, N. Y., which is just beyond the New Jersey line. The conditions are typical of the many similar occurrences that exist in the New Jersey Highlands.

W. S. Bayley.

At Tuxedo Park, Orange County, N. Y., there is a narrow strip of graphite schist that is of interest as illustrating an occurrence common in the Highlands of New Jersey. The country rock of this region is a pre-Cambrian gneiss the foliation of which strikes N. 35° E. and dips thirty to forty degrees to the southeast. It includes a lens of limestone having a maximum thickness of 250 feet and extending 3,000 feet along the strike. At its northeastern end this limestone carries a twenty foot seam of graphite schist that parallels the foliation of the gneiss, and pinches out 900 feet to the southwest with an entire loss of graphite content. Above the limestone, and carrying inclusions of it and of the schist, is a 300-foot thickness of graphitic pegmatite, which can be traced southwest beyond the limits of the limestone, where it carries a strip of graphite schist varying from five to twenty-five feet thick and holding continuously for over half a mile along the strike.

The gneiss is a rather faintly banded variety containing oligoclase, orthoclase, hornblende and quartz, with apatite and magnetite as the chief accessories (Losee gneiss of the U. S. Geol. Survey).

The limestone is coarsely crystalline, and is streaked with well developed crystals of spinel and green pyroxene. Small grains of pyrite and microscopic tourmalines are also occasionally found in it. The pegmatite occurs as outlined above, and in small masses in all the other rocks. It occurs in both coarse and fine-grained varieties, the latter of which grade into the gneiss. The rock is composed largely of quartz and feldspar, the latter excessively altered, but still showing traces of polysynthetic twinning. Graphic structure is often well developed, and the kaolinized feldspar is cut by veinlets of chlorite. When associated with the schist, the pegmatite carries flakes of graphite and microscopic fragments of a highly altered mineral that was probably hornblende. Zircon and pyrite are accessories.

The schist within the limestone, and the longer strip in the pegmatite to the southwest are alike in mineralogy and structure. It is in great part quartz and feldspar. The feldspar is principally oligoclase, but orthoclase and perthitic intergrowths are common. The quartz is in elongated masses and also in droplets and veins in the feldspar. The former variety is filled with minute inclusions, and carries much of the apatite that is a feature of the rock. The graphite is in parallel flakes, usually intergrown with biotite. In many cases the mica and graphite lie in alternating plates. Biotite is rarely found in any other relation. Cubes of pyrite are often in the vicinity of the graphite which may itself have a coating of the sulphide. If, as seems most reasonable, this schist is of sedimentary origin, it is now entirely recrystallized, and preserves no sign of its former clastic structure. Its graphite content is said to be between three and a half and four per cent.

Three hypotheses to account for the origin of the graphite suggest themselves. (1) The schist may have been an igneous rock carrying carbon as a primary constituent. This, while not impossible, is hardly probable in view of the rare occurrence of carbon in well-defined volcanics of acid composition. (2) It may be an intrusive that caught up carbon from the limestone. In this case we should expect the schist to carry graphite in

irregular patches and to give indications of high calcium content. As a matter of fact the graphite schist in the limestone grades gradually into a quartz feldspar rock of the same composition except for the absence of carbon. Moreover, absolutely no trace of limestone is found in the more extensive development of the schist to the southwest. (3) The schist may be the product of metamorphism of a sediment rich in organic matter. This view is supported by the close relationship existing between it and the limestone and by the presence of graphite disseminated through the latter rock. The pegmatite, moreover, is graphitic only when it is near the schist and where it carries fragments of this rock.

C. A. STEWART.

ON THE RAY MINING DISTRICT, NEVADA.

The Ray mining district lies about 10 miles northerly from Tonopah in Nye County, Nevada. At the time of my visit in 1904, prospecting was going on at several points and some shipping ore had been found in the Ray-Tonopah and Ray-O'Brien mines.

The general formation of the district is of sedimentary origin, and consists of a belt of siliceous schists (technically siliceous argillite) and a parallel belt of calcareous rocks, the trend of the formations being northwesterly. At the contact of these two formations, a strong lode has been formed, that of the Ray-O'Brien mine. This can be traced for half a mile or more. The ore is argentiferous galena. The dip is northeasterly at an angle of about 45°, and the mine has been opened up by an inclined shaft 300 feet deep, with 600 feet of drifts.

The age of the silicious series is uncertain but in the calcareous rocks, I found fossils which were examined by Professor J. P. Smith of Stanford University, who stated that there " seems to be a clisiophyllum, a carboniferous coral, like those in the McCloud limestone of Shasta County, California."

Mr. J. E. Spurr[1] shows the sedimentary area at Ray as being Silurian in age.

[1] Bull. 208, U. S. G. S., 1903.

The lode of the Enterprise shaft of the Ray-Tonopah mine appears to be a decomposed acid porphyry, quite similar in appearance to the rock of the hill locally known as Donald Mountain, at the south border of the district. This porphyry ore has its values chiefly in gold with some silver.

There is thus repeated in this district two well known associations of rocks and ores: In the calcareous rocks, argentiferous galena; in the acid igneous rocks, gold-silver ores.

H. W. TURNER.

REVIEWS

Die Erzlagerstätten von Pitkäranta am Ladoga-See. By OTTO TRÜSTEDT. Pp. 333, with 1 geologic map, 19 plates and 80 text figures. Bull. Com. Geol. de Finlande No. 19, 1907, Helsingfors.

This monographic report on the ore deposits of Pitkäranta, Finland, is interesting from three standpoints: as a study of contact-metamorphism, as an investigation of pre-Cambrian ore-deposits in highly metamorphic rocks, and as an application of magnetometry to the location and computation of iron-ore reserves. Briefly Pitkäranta is characterized as an iron-ore district locally rich in copper and tin ores. Mining has been in progress for nearly a century, but was brought to a sudden close in 1904, chiefly because of mismanagement and a series of untoward accidents. To show that a future exploitation of the ore-bodies must be guided by a consistent genetic hypothesis is the aim of the present report.

The oldest and really most important rock of the region is a granite gneiss regarded as of early Archæan age. This has been intruded by masses of diorite now largely converted into schistose feldspar amphibolite. Resting on the abraded edges of this complex is a great series of mica schists believed to have a minimum thickness of 2,000 meters. The lower 100 to 300 meters consists of limestones, actinolitic and hornblendic schists and dolomites. The most important members, the ore-carriers, are three horizons of dolomitic limestones, several meters thick, in part distinctly bedded and in part converted into salite masses ("Skarn") without traces of original structure. The skarn consists almost exclusively of salite with a small amount of accessory garnet, and rarely, mica, scapolite, albite, molybdenite, titanite and apatite. Locally the skarn reticulates through the limestone in irregular veins and apophyses. The basal limestone has been nearly completely converted into solid lime-silicate rock. This metamorphism is attributed to contact action due to an extensive injection of pegmatite masses. The magmatic waters found the contact between basement granite gneiss and overlying limestone a line of least resistance, and the most complete metamorphism has therefore been produced along this horizon.

Powerful dynamic stresses affected the region, kneading the limestones, disrupting the veins of skarn-infiltration, and forming autoclastic rocks. Serpentinization of the pyroxene set in, with production of

eozoon structures, and rounded the isolated skarn fragments, forming large augen in the midst of the limestones.

In late pre-Cambrian time the batholitic intrusion of the Rapakiwi granite took place, and this mass is believed to underlie the entire district at no great distance. As shown by the stratigraphic studies of Sederholm and other Fenno-scandian geologists the irruption of this magma is separated in time from the earlier intrusions by a large portion of the pre-Cambrian period.

The productive ore district is limited to a narrow zone following the main Rapakiwi contact. Ore occurs up to 3,000 meters from the visible contact, but the depth to the underlying batholithic roof is regarded as shallow. The iron ore consists of magnetite in steeply dipping beds, averaging 1 meter in thickness in the lower ore body, and 5 meters in the upper. Magnetometric measurements show that the ore bodies persist to a depth of at least 150 meters. A reserve of 12 million metric tons of magnetic iron ore containing 26 to 2 per cent. Fe is calculated.

The magnetic replaces the limestone-skarn strata and shows a preference for the unsilicated carbonate rock. Garnet, green mica, scheelite, calcite, fluorite and various metallic sulphides—zinc, copper, iron and arsenic—were introduced with the magnetite, but it is often difficult to discriminate gangue minerals from original skarn substance. The skarn is commonly serpentinized, uralitized or chloritized. Some remarkable ore-arteries which anastomose through limestone are described in detail. Cross sections of the ore-arteries show circular concentric banding, the dark-colored of vesuvianite and fluorite. Banded veins of similar composition are found to cut isolated skarn-augen that are peripherally serpentinized. By growth and coalescence of the ore-arteries large bodies of magnetite were formed. The explanation advanced for these unique features is that they are crustification phenomena produced by magmatic solutions subject to rapid changes in concentration, composition and temperature. Metasomatic replacement is also invoked, but to the reviewer the two explanations would appear to be mutually exclusive.

The tin of Pitkäranta, so frequently referred to in the literature of theoretical economic geology, is found especially in the lower skarn horizon as a filling between the skarn and gangue minerals or as a lining of cavities in the adjacent highly altered granite rocks. Of the common associates of cassiterite only scheelite is present in appreciable amounts. At the Ristaus mine the ore material consists of chondrodite (largely serpentinized), magnetite, cassiterite, scheelite, arsenopyrite and sphalerite, all of which are of synchronous development as metasomatic replacements of crystalline limestone. Tremolite veins containing cassiterite

and various sulphides, however, cut compact magnetite-serpentine ore, indicating the probability of several generations of ore deposition. At Lupikko the majority of the usual congeners of cassiterite are lacking. Extraordinarily large prismatic crystals of cassiterite up to 7 cm. in length occur embedded in massive serpentine derived from pyroxene and chrondrodite, and commonly these crystals contain large inclosures of magnetite and silicates.

The genesis of the deposits is discussed in detail, and the exposition of the author's own views is preceded by a review of the various hypotheses advanced by earlier writers. It is shown that practically every mode of origin, from eruptive to sedimentary, has been advocated. Trüstedt's own conclusions are that the ore deposits are due to intense eruptive after effects following the intrusion of the Rapikiwi granite in late pre-Cambrian time; that the mineralization was not produced by gases and vapors, but by superheated solutions; that the solutions followed previous contacts and fissures; and that ore-deposition ensued metasomatically in the limestone-skarn horizons, but chiefly in the limestones on account of their greater solubility. The ore deposits of Pitkäranta are therefore of true contact metamorphic origin, and occupy a position intermediate between the Kristiania occurrences, which are characterized by iron and copper ores, and those of Cornwall which are characterized by tin and copper—" types of deposits that have always been regarded as closely dependent upon peripheral contact-metamorphism." This last statement is open to question. The Kristiania and Cornwall deposits do not represent co-ordinate types distinguished by diverse mineralogical contents. The Kristiania deposits are held up as types formed by pneumatolitic processes, whereas the Cornwall deposits are characterized by English geologists as " purely aqueous deposits " which must have been formed long after the contact-metamorphosing activity of the irruptive granite had ceased. Viewed from this standpoint rather than from the purely mineralogical, it is more probable that the ore deposits of Pitkäranta occupy an intermediate position between those of Kristiania and those of Cornwall.

ADOLPH KNOPF.

The Copper Handbook. Vol. VII. By HORACE J. STEVENS. 8vo, pp. 1228. Published by the Author. Houghton, Mich., 1907.

The first volume of this well-known annual, a pamphlet of 330 pages issued in 1900, was based mainly on material relating to the Michigan copper mines that had been collected by the author for use that year at the Paris Exposition. From this modest beginning has gradually grown the present dignified volume, nearly four times its initial size, which essays to review the copper industry of the world. Perhaps the first

impression gained on perusal of the book is of the enormous amount of work entailed in its preparation. Along with this comes a realization of the great fund of valuable matter that it contains. The arrangement is such as to make the contents in most cases readily available for reference, and the typography—an important element in a work of this kind—is unusually accurate.

The subject is treated in twenty-five chapters comprising four main sections, and the scope of the work may be indicated by the first section of 157 pages which deals with the whole field of the copper industry, including history, geology, mineralogy, mining, milling, smelting, refining, uses, substitutes, etc., as well as a glossary of mining terms.

The second division of 100 pages treats summarily of the distribution and character of the principal copper deposits of the world.

These first two sections, which are considerably expanded from the 1906 volume, are for the most part essentially technical. They are obviously the much condensed results of wide reading, and they review in a creditable way the topics presented. From the fact, however, that the author brings to this work the training of the newspaper man rather than that of the geologist, mining engineer or metallurgist, inaccuracies and misconceptions have crept in, so that the various chapters are to be regarded more as popular descriptions than as concise scientific summaries of existing knowledge. This unfortunately applies in particular to those sections to which geologists will naturally turn. On the other hand, judicious compilation of material from countless sources has produced in certain cases valuable contributions. The chapter of 39 pages devoted to the copper deposits of the United States, for example, is the best article of similar length on this important subject that has come to the reviewer's notice. The historical matter likewise deserves commendation.

The third section, a chapter of 916 pages, lists 4,626 copper mines and companies with descriptive or critical comment on each ranging from a single word to 16 pages. This is the largest and by far the most important and useful portion of the book, and in its own field is a decided success. The scope of treatment differs from that of the recent book by Mr. Weed, "The Copper Mines of the World," in that it is rather an industrial than a geologic description of the properties considered and that in the majority of cases it rests largely on information furnished directly by the companies themselves. It also differs among other respects from Curle's "Gold Mines of the World" in that little attempt is made to discuss the financial aspect of companies beyond a statement in general terms as to the proved or probable value of the property and brief comment on the apparent integrity of the management. As a directory it is unusually complete, and while there are undoubtedly

thousands of copper mines in the world which it does not mention, there are extremely few of any importance, in this country at least, which are omitted. Regarding the important companies, in addition to location, officers, capitalization, etc., summary descriptions are given of the history, ore deposits, development, methods of working, equipment, reduction works, etc. While the descriptions are not infallible, their general accuracy and completeness are admirable, and many important facts are here recorded in print for the first time. The present volume, combined with those preceding, contains an exceedingly interesting history of the development of the Lake copper mines, with which the author is especially familiar.

The value of the book as a work of reference is somewhat lessened by the necessity of searching through 900 pages to find a mine or all the mines of a certain locality or country, but of unknown name or names. A remedy might be the inclusion of a simple list of all the mines treated, arranged alphabetically under the respective countries and states.

A matter worthy of commendation is the vigorous and fearless manner in which Mr. Stevens deals with those companies and individuals whose methods are of doubtful or bad character. His vocabulary of sarcasm and invective is at once rich and amusing, and the individuality of his style makes for effectiveness. While a few companies are possibly criticised unjustly, and some that doubtless deserve censure have not received it, every page of the book carries conviction that the author is absolutely sincere in his statements. How accurately he has judged of the honesty of the companies described may be inferred from the fact that notwithstanding his direct and forceful censure of many, he has never been obliged to defend his statements in court, while on the other hand, partly as a result of his efforts, the officers or promoters of more than one unworthy concern have felt the hand of the law.

Every reader of The Copper Handbook will be disappointed to find that the main section of the work is absolutely unchanged from the preceding year. This, as the author states, was caused by an unusual train of misfortunes which allowed time for revision of only the other portions of the book. While sympathizing with him personally on this account, the majority of purchasers will doubtless question the wisdom of issuing the present number at all. Revision of the preliminary portions may have been advisable; but the changes that had taken place in the world's copper mines in a year and a quarter made revision of the detailed mine descriptions absolutely imperative if the volume was to stand as a worthy successor of the earlier numbers. The fact that several preceding volumes have also appeared partly unrevised, notwithstanding the author's unusual capacity for work, may be taken as an indication that the keeping of the whole field up to date is too great a task

for a single man. Inasmuch as the sciences on which the copper industry rests develop by comparatively slow evolution, and have already been expounded by specialists, it seems a pity that the author's time and energy should not be devoted entirely to that particular work of a mine directory, inaugurated by him, which must be done promptly to be of value and which he seems able to do better than any one else.

General statistics of copper production, consumption, prices, dividends, etc., comprise the fourth section of 40 pages. Much interesting information is found here, together with some of less obvious importance, but in most cases apparently reliable. At the end are various estimates, scarcely to be taken seriously, of the world's copper production during the present century.

The author is to be congratulated on the large amount of effective coöperation he has received from those directly concerned with the legitimate copper mines of the world—a result due mainly to his own ability and integrity. With the changes to record that have taken place in the copper mines of the world in the past two eventful years, The Copper Handbook for 1908 will be awaited with much interest.

L. C. GRATON.

The Geology and Origin of the Lapland Iron Ores. By DR. O. STUTZER. Neues Jahrbuch für Mineralogie, etc. Beilage Band xxiv, 1907. (Journal of the Iron and Steel Institute No. 2, 1907.)

This memoir of 125 pages (with bibliography of 63 titles) affords a summary of the varying views of Swedish, German and French geologists concerning the genesis of the non-titaniferous magnetites and associated specular ores of northern Sweden. The author places himself in the ultra-Plutonic school, offering the fact that the ores are mainly inclosed by igneous rocks as the most obvious argument in favor of igneous genesis. He believes there can be no doubt that the iron ores will persist in depth contrary to the theories of earlier economists, to whom is to be attributed the present policy of the Swedish government of limiting the annual output of the Kiruna mines to 1,800,000 tons. When this limitation is removed the output of Kiruna may be indefinitely multiplied. In 1905 the Swedish mines produced 4,364,000 tons of iron ore, about three-fourths of which came from the Gellivare and Kiruna mines, the remainder being from the mines of central Sweden. Luossavara awaits development, but the great deposits of Svappavara and Leveäniemi will soon be reached by railway. The assured development of these and other deposits point to this district, lying north of the Arctic Circle, as an inestimable industrial asset.

The rocks of Lapland are all old and in the main they are highly crystalline. They include schists, limestones, quartzites and conglomer-

ates, representing metamorphosed sediments, with greenstones (diabase, diorite, gabbro), granites and syenites as igneous rocks. The syenite group includes syenite proper, syenite granulites and syenite prophyries, the iron ores being associated principally with the two latter, and most often with the porphyries. Ores occurring in the schists or quartzites are usually specularite. Definite knowledge appears lacking in regard to the age of the so-called Hauki schists and quartzites, but the older Kurravara conglomerate is thought to be of pre-Cambrian age since it seems to lie stratigraphically below Cambrian hyolithus beds. The igneous rocks are in part older and in part younger than the schists and quartzites, while in the Kiruna district the conglomerate appears as the oldest rock. The greenstones, or basic igneous rocks, cut the syenites in places, but elsewhere the relations are reversed.

Everywhere observation of the rocks is rendered very unsatisfactory because of large amounts of glacial debris and the presence of swamps and peat deposits.

While no less than twenty-one localities are described in some detail, and eleven more are briefly mentioned, consideration of a few of the principal sections of Dr. Stutzer's memoir will be sufficient to portray the difficulties encountered in reaching genetic conclusions and to enable an estimate of the extent to which these conclusions are definitive.

Kiruna.—The sedimentary rocks named above occur in association with soda-syenite and closely related porphyries. The even granular rock as represented by one analysis contains of SiO_2 59.57, of Al_2O_3 15.14, of Fe_2O_3 and FeO 7.12; while two analyses of porphyritic phases show of SiO_2 60.97 and 71.30, of Al_2O_3 15.39 and 3.53, and of Fe_2O_3 and FeO 4.48 and 4.08. Both rocks ordinarily contain more than one per cent. of titanic oxide.

Previous descriptions state that the bodies of ore are flanked by porphyries, an older gray variety on the foot and a younger red phase upon the hanging; but careful detailed work has shown that there are really several porphyries whose differences of age are so small that they may be assigned to a single period.

The ore body follows a ridge 2½ miles long called Kirunavara (Ptarmigan Mountain), the principal summit of which (Statsradet or State Councilor) is formed of solid magnetite free from any mantle of vegetation, gossan or drift. The deposit extends diagonally across the lake Luossajärvi, as known from borings and from outcrops on an island. Luossavara (Salmon Mountain) situated east of the lake and nearly on the same strike contains a separate sheet of ore 1½ kilometers long and from 30 to 55 meters wide. Judging from the sketch map the total length of the range is about 5 miles, the strike being somewhat east of north and the dip of the tabular ore bodies being stated as eastward 50

to 70 degrees. By reason of several systems of joints the ore is readily broken into blocks.

A third deposit exists in the hill Tuollavara, lying four miles east of Kiruna village, on the east side of the lake. Specular ores in the sedimentary rocks are of minor importance by comparison with the great masses of magnetite.

The amount of ore in the Kiruna deposit has been estimated at 233,000,000 tons above the lake level, with six hundred to eight hundred million tons between this and 300 meters depth.

The ore is hard, compact or massive magnetite, with 65 to 70 per cent. iron, low alumina and silica, and sulphur rarely to exceed .08. Lundbohm has classified the ores in five varieties ranging from .01-.03 up to 2.-6. per cent. phosphorus. The most noteworthy associated mineral is fluor-apatite, every possible transition from apparently clean magnetite to pure apatite being seen. The common condition where much apatite is present is a series of thin strings of this mineral forming a network through the ore. Wider lenticules of apatite, usually running parallel with the prevailing country strike, may include fragments of magnetite showing fluxional arrangement. In places strings of apatite are transected by stringers of magnetite.

Where the two minerals are intermixed, as a rule the magnetite was evidently first crystallized. Next to grains or masses of apatite the magnetite is more dense and brilliant and also more free from phosphorus than elsewhere, a relation which is thought to indicate liquation as the process by which the apatite became partially segregated from the molten magnetite in which it had been dissolved. The apatite individuals often contain minute inclusions of specularite or magnetite, but on the whole the magnetite and apatite seem to have crystallized contemporaneously. Other inclusions in the apatite are faldspar, tourmaline and limpid needle-like forms which may be xenotine, rutile or zircon. Calcite is noted in dikes of syenite porphyry and locally in the ore which may also contain hornblende, mica, talc and chlorite, the two latter formed by alteration of hornblende. At one locality magnetite younger than corroded hornblende is noted. The only quartz observed is evidently secondary.

The genesis of the Kiruna ore can be determined only by fixing the nature of the inclosing rock. All students have considered the iron in these ore masses as having been derived from the same source as the porphyry, so that diversities of opinion have turned mainly upon methods of transport. The suggestion of Bäckström that the porphyries are recrystallized tuffs is set aside on convincing evidence, which includes the indubitable close relation between them and the even granular syenite. The observed gradation from syenite into syenite-porphyry strongly

indicates intrusion rather than extrusion as the method by which the immediate country rock reached its present condition. Full acceptance of this view is, however, challenged by apparent conformity between the schist-quartzite beds and the porphyry, which relation, if actual, leaves the invading mass without a determinable hanging wall on the east side of the ore range. The author suggests that the matrix for the intrusion may be represented by an included block of quartzite which is observed on the east slope of Luossavara and imagines the main contact to lie further east beneath the metamorphosed sediments. The abbreviated form necessary in presenting so great a mass of data leaves the reader with a strong doubt of the validity of the conclusion that these sediments are in fact younger than the porphyry. If younger, how could they contain, as stated, veins of red feldspar certainly connected with the porphyry and alleged intrusive apatite-magnetite masses? A strong unconformity within the schist quartzite complex affords basis for the suggestion, which is not developed by the author, that the schists of the older division constitute the true country rock of the porphyry.

Outlining the thinkable modes of genesis the author dismisses all but the magmatic division of the primary class in which the metal is derived from the interior of the earth. "Magnetite of the neighborhood of Kiruna is genetically connected in the most intimate manner with the accompanying keratophyres. Like these porphyries it is of magmatic origin and has been injected at a relatively contemporaneous period." The most convincing of eleven arguments in favor of the above conclusions are: that the porphyries on both sides of the ore body are locally traversed by good-sized streaks of compact magnetite free from druses; that smaller isolated streaks of magnetite accompanied by hornblende, apatite and sphene exhibit no feeding channels and, no reason being apparent for substitution phenomena, this relation indicates that the magnetite solidified before the body of the rock but after the feldspar crystals which protrude into the ore; that locally a transition is observed between the porphyry and the ore, the silicates containing more and more iron as the ore is approached, the apparent idea of the author being that an interchange of material ensued between the ore magma and the inclosing porphyry magma. The several magmas are evidently regarded as essentially contemporaneous, but the porphyry lying beneath the ore appears to have reached a relatively solid condition prior to the ore magma. The form of this conclusion given here is not exactly that of the author, who states these relations only in his section on the Kiruna porphyries and not in the discussion of genesis. That the hanging wall porphyry is newer than the ore is argued from the presence in it of fragments of the ore and fragments also of the footwall porphyry.

The interpretation of the relations exhibited by apatite and magnetite

being that they separated by a process of liquation, a mutual solution of these substances, or in other words a magmatic condition of the ore material, is indicated, though this train of reasoning must be read between the author's lines.

A certain amount of pneumatolitic action is suggested by films of magnetite traversing the feldspar of the wall rocks.

Nowhere does the author sufficiently state the structural features of the ore district and no attempt is made to account for the tabular form of the ore bodies. It seems that the minor masses of ore in the metamorphosed sediments might be expected to furnish contributory genetic evidence in line with the magmatic hypothesis, and one regrets that the author has not developed this side of the problem.

Ekstromsberg.—The Ekstromberg deposits lie about 20 miles west of Kiruna. The ore bodies are inclosed by syenite porphyries and, like the Kiruna deposits, are regarded as of magmatic origin. Throughout the district the strikes are northwesterly and the dips steep toward the southwest. Both the porphyries and the ore are thought to be extrusive: the porphyries because of marked fluxional structure, and the ores presumably because of their close physical association with these. Here, however, the author enters disclaimer on the ground of the short time devoted to the district.

Turning back to the description of the Kiruna porphyries the reader will find that they, too, exhibit fluxion, though this is not argued against their intrusive nature. In the Ekstromsberg districts certain deposits are bordered by important masses of contact minerals, the origin of which is tentatively referred to gabbro invasions later than the formation of the ores.

Gellivare.—The mountain Gellivare Dundret, lying just north of 60° N. latitude and 6½ miles south of the mining town Malmberget, is visited yearly by tourists coming to view the midnight sun between the dates June 5 and July 11. North of this gabbro mountain is a district of soda-syenite gneisses in which occur numerous bodies of magnetite with associated minor amounts of specularite. The principal constituent of red phases of the gneiss is albite, while grey gneiss contains in addition microperthite, and both varieties grade into biotite and hornblende phases. Granite younger than the gneisses are much like them in that they are rich in soda and possess gneissic structures. They are different, however, in containing quartz and in being of coarser texture. Both rocks are said to be evidently metamorphosed. The granite masses follow the common trend and appear to have pressed the ore and containing rocks aside during the period of metamorphism. The possibility that the structure of the gneissoid granite may have developed during invasion and before its complete crystallization is not considered. Peg-

matite veins essentially free from gneissic structure penetrate the ore, the gneiss and the granite. The pegmatites contain quartz and red feldspars, usually apatite and specularite, and in places fluorspar and calcite.

The ore bodies, which are plotted on a special sketch map, are disposed in curving and roughly concentric ranges or groups. Of these, the most northerly showing the greatest approach to continuity, is 4½ miles long, while the others are considerably shorter. The southernmost and shortest range yields ores especially low in phosphorus. The general trends are east and west, but there are many local variations in strike. Dips vary from 30 to 70 degrees toward the south. Most of the ore is made up of granules like rice grains. A parallel arrangement of the ore and bands of apatite follows the strike of the deposits and must be regarded as the result of pressure. Here the reader thinks of applying the hypothesis of liquation appealed to by the author in explaining the relation of apatite and magnetite at Kiruna.

The accordance of attitude between the different rocks is not invariable, deviations of dip being rather more notable than those of strike. In places numerous dikes within the deposit give rise to coarsely banded parts made up of alternating layers of ore and granite. Next the ore the granite exhibits the same sharp walls as where it traverses other rocks. Deformation is evidenced by inclusions in the ore mass which appear to have been broken and filled in with apatite and magnetite, then drawn or flattened out. Unlike the granite the gneiss near the ore bodies is often impregnated with magnetite, sometimes with associated hornblende.

The ore bodies have lenticular form and their lenticules often overlap. Occasionally the larger bodies split, and branching is often seen in minor masses. A table of analyses given represents over 500,000 tons of ore mined in 1904.

The commonly stated sedimentary origin of the Gellivare ore may be put aside at once upon accepting the igneous origin of the containing rocks. That the red gneiss is igneous is indicated by its uniformly developed nature and its mineralogical composition which is like that of the abundant soda-syenites of Lapland (here again the reviewer reads between the author's lines). It is rendered more evident by certain residual structures in masses of so-called porphyritic gneiss, which is really soda-syenite of the same kind as that containing ores at Kiruna and Ekstromsberg. Analogies with Kiruna are argued to show that the ore bodies were formed as magmatic fillings, by which the author seems to signify essentially normal intrusion. The mineralogy of the Gellivare ores is more fully described than that of the other districts.

Svappavara.—The Svappavara district, lying about 30 miles southeast

of Kiruna and 50 miles north of Gellivare, was the first known mineral locality in Norbotten province. Copper ores discovered about 1640 were worked until 1745. Occurring as it does near the copper, the iron ore must have been known as long, but iron mining and smelting appears to have begun in 1707, just 200 years prior to the establishment of the present extensive works.

Crystalline limestone, gabbro and syenite granulite constitute the country rocks. The older grey granulite carries calcite, while the younger reddish granulite is particularly characterized by the presence of scapolite. The copper ores are mainly associated with the scapolite rocks which contain besides copper pyrites, brown mica, augite, tourmaline, apatite and magnetite. Such sulphides as occur with the iron ores are confined to the walls of the deposits.

The ore deposits contain magnetite and specularite in the ratio of about 2 to 3. The principal deposit strikes north and south and stands nearly vertical, the outcrop being 770 m. long. The northern half is magnetic, but on the summit of Svappavara magnetite gives place to specularite. Other bodies of specular ore within the range are 125 m. long, 15 m. wide; 60 m. long, 20 m. wide; 133 m. long, 20 m. wide; giving for the range a total length of 1,300 m., with a computed area of 15,000 square meters, and yielding 190,000 tons per meter depth. The gangue minerals are mainly apatite and calcite, the former occurring either diffused as invisible grains or aggregated in lenticules 2 to 12 cm. broad and up to 3 m. long. By reason of somewhat abundant yellowish red calcite concentration there results a spotted ore. In places calcite veins and lenticules penetrate the ore producing the effect of a cemented breccia. Finely granular apatite is inclosed by calcite and also veins of apatite break through calcite masses. An average analysis of the better magnetic ore is 61 per cent. iron, 1 per cent. phosphorus, 6 per cent. calcite.

The contacts between ore and grey granulite, where small veins of ore penetrate the rock, speak for epigenetic origin, contrary to the views of De Launay who has regarded nearly all the Lapland ores as deposited by sedimentation. The purity of the ore (apparently meaning the high degree of concentration of the iron oxide) is further evidence in favor of magmatic origin, and the similarity of both varieties of granulite makes them both igneous and precludes the sedimentary theory. It seems possible that the calcite in the ore (and in the grey granulite?) has been taken up from limestones occurring in the vicinity. Such magmatic crystalline limestones are known is several localities in Sweden, notably on the island Alnö.

The author states that a satisfactory explanation of the Svappavara ores has not been reached and the tentative conclusion that they are magmatic is based on analogies with other localities. To the reviewer

it seems that Svappavara, the only locality within the ore fields of Swedish Lapland where ancient limestones occur, may offer an example of a stage in iron ore genesis not represented in other localities, but still a stage through which many of the deposits may have passed. Taking the rocks and ores of Svappavara as they now exist, restoring a great mass of eroded material, renewing telluric activities of the sort manifested by the presence of soda-syenite, and appealing to the theory of granitization (as developed by the French school under Lacroix), the action of magmatic juices upon the limestone of this locality might convert this mass into a rock having the composition of soda-syenite. Under this process the product would become a second Kirunavara.

Mertainen.—At Mertainen, nine miles northwest of Svappavara, the country rock of syenite porphyry or granulite shows every possible gradation with the magnetite ore. The iron oxide occurs as reticulating veins inclosing angular fragments of the rock with their edges somewhat altered. The nature of this characteristic breccia is shown by a photograph which, however, is not so striking to the eye as one given in Lundbohm's Bulletin of 1898. First remarking that in certain diabases and basalts magnetite appears as the latest crystallization, the author says that when the magnetite is diffused in small quantities it appears among the first minerals separated, but when it falls together in large masses it consolidates later and forms a matrix for the silicates. From this it is assumed that at Mertainen the enclosing feldspathic porphyry consolidated before the banded aggregates of magnetite, and that the latter while still fluid was injected into cracks and fissures of the rocks.

Though the features of the Mertainen deposits are not especially emphasized in the author's discussion, it appears that, of all the deposits described, these present the most unequivocal evidence of igneous injection. The interested reader should consult the Swedish Survey bulletin by Lundbohm.

The nontitaniferous magnetite deposits of the pre-Cambrian districts of the Adirondack mountains and of the New York and New Jersey Highlands exhibit many resemblances to those of Lapland. Gneissoid syenites and granites rich in soda feldspar are associated with a large number of the ore bodies, but in general the latter are not confined to these rocks. The typical form of the ore masses is tabular and with few exceptions the ore layers conform to the strongly marked layering of the enclosing rocks.

Though our pioneer geologists considered the pre-Cambrian magnetites of the eastern states to be igneous dikes, later workers came to regard the layering of the old gneisses, the accordant attitude of the ore masses, and the presence of limestones in the complex, as indubitable

evidence of sedimentary relationships. Certain of the ore-bodies in the Adirondack region are enclosed by granitoid gneisses, and for these Cushing and Newland conceive a magmatic origin. Cushing draws analogy between the association of the titanic ores with gabbro and that of the nontitanic ores with more silicious plutonic rocks, pointing thus to separation by magmatic differentiation. Newland emphasizes consideration of the fact that the magnetites occur both in igneous and metamorphosed sedimentary rocks. The former have originated within the existing wall rocks, and they are regarded as magmatic differentiates. Contributary action of gases and solutions is suggested, and, while this writer does not so state, these agents may be appealed to in explanation of certain epigenetic ore-bodies in sedimentary rocks. The Mineville magnetites are classed by Kemp as contact deposits.

Coming to the study of the New Jersey magnetites after several years apprenticeship among the igneous rocks of the west, the present writer was at first inclined to regard all of the gneisses of the district as of magmatic origin, and to regard the ores as extreme phases of rock differentiation. Opportunity to see the Grenville sediments and their products under the influence of great igneous intrusions in Hastings and Haliburton counties, Ontario, under the guidance of Professor Adams, led to modification of extreme views and to the recognition that certain phases of the Highlands gneisses might well be granitized sediments instead of magmatic differentiates. Certain of the magnetite deposits, in addition to the few occurring in limestone, are now regarded as epigenetic (and probably metasomatic), while both segregation in situ, and migration of highly ferriferous magmas from the locus of their differentiation, are held as the most plausible theories for explaining those ore masses which are enclosed by magma gneisses.

The present consensus of opinion regarding our eastern magnetites is thus in essential accord with the findings of Dr. Stutzer in his field. Though we are now coming to recognize the preponderating importance of plutonic agents in the formation of these pre-Cambrian ores, such recognition is merely one step in the right direction. The phrase "magmatic differentiation" covers much ignorance which we may hope to see slowly dispelled. With the fulfillment of this hope will come real progress in solving the enigma of the magnetite ores of the pre-Cambrian complex.

A. C. SPENCER.

Cement and Portland Cement Materials of Mississippi. By ALBERT F. CRIDER, Director Mississippi State Geological Survey (Bulletin No. 1: 73 pp. and map, 1907).

This report is the first of the new series of bulletins issued by the recently reëstablished State Geological Survey of Mississippi. As its

title suggests, it is devoted, first, to a general consideration of cements from the historical, industrial and technologic standpoints, and, second, to a discussion of the Portland cement resources of the State of Mississippi. About one third of the bulletin is devoted to the subject of cements, particularly Portland cement, and calls attention to the heretofore little appreciated fact that the South produces less than 4 per cent. of the total quantity of Portland cement manufactured in the United States.

An error into which many *promoters* of cement manufactories have fallen, but which should have been guarded against in a State report, is contained in the overestimate of the quantity of cement to be required by the construction work of the Panama Canal (page 15). The latest official figures are stated[1] to be only about 4,500,000 barrels, or less than half the quantity mentioned.

Although the report presents nothing new regarding the technology of cement-making, and, in fact, very little of the more recent information on this phase of the subject, it nevertheless outlines the general principles and methods of cement manufacture so clearly and concisely that the possibilities and limitations of development of local raw materials may be readily understood by the business man who has not previously looked into the cement industry. The report is judiciously illustrated by half-tones which show the character of many of the outcrops described.

In his discussion of the ingredients used in the manufacture of Portland cement, Mr. Crider has selected for comparison the analyses of typical raw materials used at successful plants in various parts of the United States, and shows in his local descriptions that certain of the chalks, marls, limestones and clays of Mississippi compare favorably with, and in some instances are perhaps superior to materials in use, so far as chemical composition is concerned. Under "Fuels" is suggested the possibility of utilizing Mississippi lignite for generation of power through the gas producer and gas engine, but no hazard is made as to the possibility of using this producer gas as a fuel in the kilns—where is required probably two thirds of all the fuel needed to operate a cement plant. Proximate analyses of twelve Mississippi lignites are given, without stating from what localities they were obtained, nor upon what basis they were analyzed. The moisture ranges from 8.72 to 14.9 per cent., the volatile matter from 34.61 to 42.38, the fixed carbon from 31.24 to 42.47, and the ash from 6.37 to 15.40. Assuming that these analyses were made on air-dried lignite, they indicate that the material is capable of producing a good yield of gas, and an opportunity appears to exist here for experimental work on the part of the survey to deter-

[1] Press Bulletin U. S. Geol. Survey No. 320, Feb. 24, 1908.

mine the heat value of this gas, and whether it could be sufficiently enriched by hydrocarbons or by water gas to make a kiln fuel.

The local relations of fuel to suitable rock, and to transportation routes are, unfortunately, not discussed by this paper, an omission not entirely compensated for by Bulletin No. 3 of the Mississippi Survey, which describes the lignites of the state.[1]

The Portland cement materials of Mississippi are found in rocks of the Devonian, Carboniferous, Cretaceous and Tertiary systems. As a factor in the situation, the Devonian and Carboniferous shales and limestones are not considered of as great importance as the chalks, limestones, and clays of Cretaceous and Tertiary age, owing to the limited distribution of the former in the extreme northeastern edge of the state. There are, however, materials here well situated with reference to transportation facilities, since they are adjacent to Tennessee River as well as railroads. Both sections and analyses of these materials are given. According to the analyses the Devonian limestones are so highly siliceous that the addition of pure limestone would be necessary.

In the Cretaceous system the highly important formation is the Selma chalk. The Selma chalk occurs in a belt 10 to 15 miles wide and 150 miles long, crossing the northeastern part of the state. This rock may be separated into three divisions, vertically, based primarily on chemical composition: (*a*) The sandy basal portion; (*b*) the bluish, argillaceous middle portion; and (*c*) the rotten limestone and chalk found in the upper portion of the formation. The lower portion of the Selma is not suitable as a cement material, on account of the large amount of free silica which it contains. Higher up the formation shows increasing percentages of lime and correspondingly decreasing percentages of silica. Detailed sections of a large number of outcrops of this rock are given, supplemented by analyses of the material from various localities. The total thickness of the Selma reaches as much as 800 feet in Mississippi, but the suitable, upper portion is only a fraction of that thickness. The available limestone material varies in composition to such an extent that some of it instead of requiring the addition of clay requires the addition of a purer limestone for Portland cement mixture. There are two sources of clay for use with the Selma chalk, *viz.*, residual clay from the Selma chalk and the Porters Creek clay. The successful use of Selma residual clay at the plant of the Alabama Portland Cement Company at Demopolis, Ala., is cited.

In the Tertiary system the Porters Creek clay, the Jackson marl and the Vicksburg limestone are of greatest value for cement making. The Porters Creek clay overlies the Selma formation in places, and in other

[1] Brown, Calvin S., "The lignite of Mississippi," Bull. 3, Miss. State Geol. Survey, 1907, 71 pp.

places the Ripley and Clayton limestones intervene between the Selma and the Porters Creek. On the geologic map of Mississippi the Porters Creek clay has not been shown separately, but it is included in the mapping of the Midway group. Promising localities where it occurs are mentioned in the report, but statements as to the thickness of this clay seem to have been omitted. A sufficient number of analyses are given to show that the material is a highly siliceous clay—possibly too highly siliceous in places, as the ratio

$$\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$$

exceeds 4.5 in some instances, whereas it does not fall below 2.27 in any of the analyses given.

Attention is called for the first time to the calcareous marls and residual clays of the Jackson formation as a possible source of Portland cement material, particularly at Yazoo City and Jackson, and the material appears to possess the merits of quality, quantity and convenient location.

The Vicksburg limestone is, however, considered to be the most valuable of the Tertiary formations in this connection, and on this material, in the vicinity of Vicksburg, was done the most thorough work of the Survey. The rock consists of alternating strata of limestone and marl, and a section showing 31 feet of the material, divided into eight separate ledges or units 2 to 5 feet thick, was sampled in detail and analyses obtained from each of the first seven units. The average of these analyses shows close correspondence to the composition of actual mixes used in several American cement plants. In addition a small fragment of limestone from each ledge was pulverized, an analysis made of the mixture, and a similar analysis was made from a mixture of samples from the marl strata in the same section. An average was then made of these two analyses and it was found to compare closely with the compositions of the mixes mentioned above. It is to be regretted that these series of tests could not have been supplemented by an analysis of a single sample composed of cuttings from the complete face of rock, just as it would be quarried in practice.

The Vicksburg formation has an important areal extent and distribution. It is exposed in bluffs overlooking Yazoo and Mississippi rivers near Vicksburg, and occupies a narrow belt crossing the State from west to east just south of the latitude of Jackson. It is well exposed on Pearl River, also at several places where crossed by railroads farther east.

In conclusion Mr. Crider has summarized the natural advantages offered for the location of a Portland cement plant at each of nine important places in Mississippi, viz., in Tishomingo County where the

Southern railway crosses Bear Creek, and at Mingo Bridge; at Starkville, West Point, Columbus, Bryam, Plain, Rankin, and at Vicksburg. This is a specially valuable feature of the report, and it would appear to express a conservative, practical viewpoint of the situation rather than to overestimate the Portland cement manufacturing capability of the state.

Undoubtedly the value of the report would have been greatly increased by a fuller discussion of the analyses presented, by suggestions as to the combination of certain clays and limestones, by descriptions of quarrying conditions, by notes on the lignites possibly available in connection with the rock, by experimental work on these fuels, and in making clinker and cement from the raw materials recommended. The report in no way encroaches on the field of the engineer, and, as it stands, comes nearer fulfilling than falling short of fulfilling the function of a geological survey report, inasmuch as it embodies the results of a broad reconnaissance of this special field, and points out in advance of exploitation a very valuable resource of the state.

ERNEST F. BURCHARD.

WASHINGTON, D. C., May 20, 1908.

RECENT LITERATURE ON ECONOMIC GEOLOGY.

COMPILED BY

G. F. LOUGHLIN.

METALLIFEROUS DEPOSITS.

COPPER.

Foothill Copper Belt of the Sierra Nevada. Reply by J. A. REID to criticism by O. H. Hershey. Min. and Sci. Press. Vol. 97, No. 2, p. 48, 1908.

Contends that value of the mines depends chiefly on the primary rather than on secondary sulphides.

The Mineral Resources of the Kotsina and Chitana Valleys, Copper River Region. By F. H. MOFFIT and A. G. MADREN. U. S. G. S. Bull. No. 345, 1908, pp. 51.

Results of last season's work, giving general geology and relations between copper ores and associated rock.

Copper Deposits on Kasaan Peninsula, Prince of Wales Island. By C. W. WRIGHT and S. PAIGE. U. S. G. S. Bull. No. 345, 1908, pp. 18.

Describes geology, ore deposits and mines.

Notes on Copper Prospects of Prince William Sound. By F. H. MOFFIT. U. S. G. S. Bull. No. 345, 1908, pp. 3.

Brings out favorable location of the properties.

Los Yacimientos cupriferos de Huitor (Cañete) (Peru). By J. J. BRAVO. Boletin de Minas, Lima, Peru. Apr. 10, 1908, pp. 5.

Describes geology and occurrences of copper ore in the coastal regions of Peru.

GOLD AND SILVER.

Notes on Some Gold Deposits of Alabama. By H. D. MCCASKEY. U. S. G. S. Bull. No. 340-A, 1908, 17 pp.

Describes geology and ore deposits; gives production and some detailed descriptions.

The Mineral Deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Arizona. By F. C. SCHRADER. U. S. G. S. Bull. No. 340-A, 1908, 31 pp.

Includes general description of region, and detailed discussion of geology and ore deposits.

Gold Placer Deposits near Lay, Routt County, Colorado. By H. S. GALE. U. S. G. S. Bull. No. 340-A, 1908, 13 pp.

Gives general geology, and the distribution, character and origin of the deposits.

Treasure Mountain, Colorado. By C. W. PURINGTON. Min. and Sci. Press. Vol. 97, No. 1, pp. 23–25, 1908.

Describes the occurrence of some remarkably wide vein-quartz bodies in andesite, and attributes size to silicification of wide crushed zones.

Rock Oxidation at Cripple Creek. By P. ARGALL. Min. and Sci. Press. Vol. 96, No. 26, pp. 883–886, 1908.

After description and discussion of Gold Hill properties and Deerhorn claim, writer suggests the following succession of events: (*a*) fissuring, followed by an early solfataric stage; (*b*) solfataric stage marked by the striking deposit of gypsum; and (*c*) the oxidation, or weathering, period.

Geology and Mineral Resources of the Osceola Mining District, White Pine County, Nevada. By F. B. WEEKS. U. S. G. S. Bull. No. 340-A, 1908, 16 pp.

Gives general geology, history, mining, ore genesis, and distribution of mines.

Geological Possibilities at Goldfield. By A. BECKER. Min. and Sci. Press. Vol. 96, No. 25, p. 846, 1908.

Shows the presence of a second, lower dacite sheet, thought to be of same origin, and to contain same mineralization, as the first dacite, thereby greatly increasing the total amount of ore already known to exist.

Mines of the Riddles Quadrangle, Oregon. By J. S. DILLER and G. F. KAY. U. S. G. S. Bull. No. 340-A, 1908, 3½ pp.

Discusses geology and ore deposits and describes some principal mines.

Gold Deposits of the Little Rocky Mountains, Montana. By W. H. EMMONS. U. S. G. S. Bull. No. 340-A, 1908, 20 pp.

Gives history, geology, ore deposits, character of ore, and detailed descriptions of some mines.

The North Side of the Coeur d'Alene District. By H. S. AUERBACH. E. and M. Jl. Vol. 86, No. 2, pp. 65–70.

Gives a good summary account of geology and ore-bodies, and details

of some districts in the less familiar portion of the Coeur d'Alene. Lead, silver, and gold deposits have promising future.

The Fairbanks and Rampart Quadrangles, Yukon-Tenana Region. By L. M. PRINDLE. U. S. G. S. Bull. No. 337, 1908, pp. 102.

Gives general and economic geology, and describes the several groups of placers.

The Gold Placers of Parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope Precincts. By A. J. COLLIER, F. L. HESS, P. S. SMITH, and A. H. BROOKS. U. S. G. S. Bull. No. 328, pp. 343, with maps and illustrations. Washington, 1908.

Investigations of the Mineral Deposits of Seward Peninsula. By P. S. SMITH. U. S. G. S. Bull. No. 345, 1908, pp. 47.

Discusses increased activity in prospecting for placer and lode deposits. No new bonanzas found.

Occurrence of Gold in the Yukon-Tanana Region. By L. M. PRINDLE. U. S. G. S. Bull. No. 345, 1908, pp. 9.

Prospecting and Mining Gold Placers in Alaska. By J. P. HUTCHINS. U. S. G. S. Bull. No. 345, 1908, pp. 24.

Discusses progress in prospecting and mining, including working of frozen ground, churn drills, necessity of accurate sampling, shaft prospecting, hydraulic, open-cut, drift mining, and dredging.

The Forty-Mile Gold Placer District. By L. M. PRINDLE. U. S. G. S. Bull. No. 345, 1908, pp. 11.

Describes geography and geology; discusses origin of gold, mining developments and production in the district.

Ores and Mines of Santa Eulalia, Mexico. By C. T. RICE. E. and M. Jl. LXXXV., No. 26, 1908, pp. 1283–1286.

One page devoted to character of ores; remainder to mode of occurrence at the different mines.

A Geological Analysis of the Silver Production of the United States for 1906. By W. LINDGREN. U. S. G. S. Bull. No. 340-A, 1908, 13 pp.

Gives geological conditions and discusses output of ores according to their classification into silver-base metals, siliceous silver, silver-lead-copper, silver-gold, and silver ores.

LEAD AND ZINC.

Lead and Zinc in the United States. By W. R. INGALLS. Pp. 368, illustrated. 6¼ × 8¼ in.; cloth, $4. New York and London, 1908. Hill Publishing Company.

A history of lead and zinc, prepared at request of the Carnegie Institution as a part of the Economic History of the United States.

TIN.

The Seward Peninsula Tin Deposits. By A. KNOPF. U. S. G. S. Bull. No. 345, 1908, pp. 17.

Summarizes geological investigations since 1906, and limits most encouraging prospects to extreme western part of the Peninsula.

The South African Tin Deposits. By W. R. RUMBOLD. Trans. A. I. M. E. Bi-Mo. Bull. No. 22, 1908, pp. 601–607.

Briefly describes and discusses the typical geology and commercial unimportance of the three known tin fields.

NON-METALLIFEROUS DEPOSITS.

COAL.

The Origin of Coal. By H. M. CHANCE. E. and M. Jl. Vol. 86, No. 1, 1908, pp. 27–28.

Directs attention to some observed peculiarities of coal beds and associated rocks not satisfactorily explained by any heretofore proposed theories.

Coal from the Standpoint of the Engineer. By G. H. ASHLEY. Sibley Jour. of Eng. May, 1908, 7½ pp.

Treats of composition and character, purchase and use of coal.

GRAPHITE.

A Contribution to the Discussion of the Graphite in Argenteuil and Labelle Counties, in the Province of Quebec. By F. HILLE. Can. Min. Jl. Vol. 29, No. 15, 1908, pp. 361–363.

Condemns the four hypotheses brought out in H. P. Brumel's paper and in the resulting discussion, and names diabase as the source of the graphite.

PETROLEUM.

Das Erdöl von Helfta bei Eisleben (Briefl. Mitt.). By F. HORNUNG. Zeit. der Deut. Geol. Ges. 1907, Monatsber. No. 4, pp. 115–122.

Ein vorkommen von tropfbar flüssigem Erdöl im Kupferschiefer des Ostharzes, . . . gibt ihrn Veranlassung, auf litztere zurückzukommen und unter Widerlegung einer inzwischen von anderer Seite aufgestellten, z. T. "dynamischen" Petroleum-bildungstheorie seine reine chemische aufrecht zu erhalten.

BUILDING STONE.

The Building Stones and Materials of Southeastern Alaska. By C. W. WRIGHT. U. S. G. S. Bull. No. 345, 1908, pp. 11.

Discusses marble, granite, gypsum, and cement rock.

Natürliche Bausteine. By A. SCHMIDT. Pp. 174 and 53 text figures; Hannover by M. Jänecke. (Bd. 76 der Bibl. d. gesamten Technik.)

A general treatise on building stones. Discusses rock-forming minerals and rock structures; properties of building stones; rock composition; composition and properties of the several igneous, metamorphic, and sedimentary rocks; the quarrying and working of stone.

Die Prüfung der naturlichen Bausteine und ihre Wetterbeständigkeit. By J. HIRSCHWALD.

I.: Die Verwitterungsagenzien und ihr Einfluss auf die natürlichen Bausteine.—II.: Die Methoden zur Prüfung der Gesteine auf ihren Wetterbeständigkeitsgrad.—III.: Die Bewertung des Einflusses, den die verchiedenen Eigenschaften des Gesteines auf ihre Widerstandsfähigkeit gegen Witterungseinflüsse ausüben.—IV.: Die systematische Prüfung der natürlichen Bausteine auf ihren Wetterbeständigkeitsgrad und die Ergebnisse dieser Prüfung an Gesteinsmaterialien älterer Bauwerke. Berlin, W. Ernst and Son, 1908. Pp. 675, with 54 plates, 4 colored plates, and 133 figures. Price M 36.

WATER.

A Preliminary Report on the Underground Waters of Georgia. By S. W. MCCALLIE. Geol. Surv. of Georgia. Bull. No. 15, pp. 370, illustrated. Atlanta, Ga., 1908.

Water Supply of the Fairbanks District, 1907. By C. C. COVERT. U. S. G. S. Bull. No. 345, 1908, pp. 8.

Investigations to determine total flow and distribution of flow during open season, and data on conditions affecting water supply and its development.

Water Supply of the Nome and Kougarok Regions, Seward Peninsula, 1906–7. By F. F. HENSHAW. U. S. G. S. Bull. No. 345, 1908, pp. 14.

Describes systematic measurements to determine total flow and distribution of flow during the open season. Facts regarding conditions affecting water supply. Statistics on division and use of water.

ORE DEPOSITS AND RELATED SUBJECTS.

Diffusion as a Factor in Ore Deposition. By L. T. WRIGHT. Min. and Sci. Press. Vol. 96, No. 25, pp. 844–845, 1908.

First half discusses the failure of Soret's principle of magmatic segregation to account for certain ore bodies, illustrating by consideration of the behavior of cooling slag from a copper-smelting furnace; second half discusses the efficiency of osmotic pressure or diffusion as a concentrator of certain deposits, and states belief that the process must have been frequently in operation, though not necessarily the chief agent of deposition.

Discussion by H. H. KNOX. Min. and Sci. Press. Vol. 97, No. 5, p. 149, 1908.

Briefly upholds Soret's principle in the case of plutonic rocks where the time element may be very great.

Waters, Meteoric and Magmatic. (Discussion of Prof. Kemp's paper.) By T. A. RICKARD. Min. and Sci. Press. Vol. 96, No. 26, pp. 872–875, 1908.

Discussion practically confined to meteoric waters. Abundant evidence cited proving the shallowness and irregular bottom of the ground water zone, and the existence of an intervening dry zone of indefinite thickness between the shallow ground water and abyssal magmatic water zones. The general non-persistence in depth of ore deposits is pointed out, and their intimately associated position with that of the meteoric (ground) waters favors the belief that the latter are the chief agents in the formation of ores.

Discussion by H. W. HIXON. Min. and Sci. Press. Vol. 97, No. 3, p. 82, 1908.

Points out that G. Poulett Scrope, in 1825, was the first to ascribe ore formation to magmatic waters in his "Considerations on Volcanoes," published in London in 1825.

Uber Kaolinbildung, einige Worte zur neuesten Literature. By H. RÖSLER. Zeit. f. Prakt. Geol. Jg. XVI., H. 6, 1908, pp. 251–254.

Criticizes five other papers on kaolinization. Supports the *"Grauerden"-Theorie,* which refers kaolinization to pneumatolytic and pneumatohydatogenic processes, and regards the old theory, that kaolin is a product of normal weathering, as untenable.

Beitrage zur Kenntnis der Bergschläge III. By A. RZEHAK. (Continued from Jg. XV., 1907, p. 293.) Zeit. f. Prakt. Geol. Jg. XVI., H. 6, 1908, pp. 237–250.

Reviews several articles dealing with spontaneous rock fracturing in quarries, mines, and tunnels.

Das Innere der Erde und der Planeten. Mathematisch-Physikalische Untersuchung. By H. WEHNER. Freiberg in Saxony, 1908, Craz and Gerlach. Pp. 74, with 27 figures. Price M. 2, 50.

Dip and Pitch. (Discussion of previous article.) By R. W. RAYMOND and H. LOUIS. Trans. A. I. M. E. Bi-Mo. Bull. No. 22, 1908, pp. 609–614.

Brings out difference of opinion regarding "pitch" in ore bodies and calls for general discussion.

REGIONAL.

The Mining and Quarry Industry of New York State. By D. H. NEWLAND. N. Y. State Mus. Bull. No. 120. Pp. 82, Albany, 1908: University of the State of New York.

The Mining Industry in North Carolina during 1906. By J. H. PRATT. No. Car. Geol. and Econ. Surv. Economic Paper No. 14, 1907, pp. 142.

Contains descriptions of the producing gold mines, discussion of occurrence of mica, and general discussion of minerals and metals, with statistics.

Geology and Mineral Resources of the Controller Bay Region, Alaska. By G. C. MARTIN. U. S. G. S. Bull. No. 335, pp. 141, with maps and illustrations. Washington, 1908.

Mineral Resources of Alaska: Report on Progress of Investigations in 1907. By A. H. BROOKS and others. U. S. G. S. Bull. No. 345, pp. 285; illustrated. Washington, 1908.

The Mining Industry in 1907. By A. H. BROOKS. U. S. G. S. Bull. No. 345, 1908, pp. 24.

Discusses progress and includes statistics of production in Alaska.

Lode Mining in Southeastern Alaska, 1907. By C. W. WRIGHT. U. S. G. S. Bull. No. 345, 1908, pp. 21.

Discusses geology, ore deposits, and prospects of gold, silver, copper, lead, and zinc.

The Mineral Deposits of the Lost River and Brooks Mountain Region, Seward Peninsula. By A. KNOPF. U. S. G. S. Bull. No. 345, 1908, pp. 4.

Describes prospects for tin, silver-lead, tungsten-lead, copper, and perhaps gold.

Geology of the Mining Districts of Chihuahua, Mexico. By R. M. BAGG, JR. Min. and Sci. Press. Vol. 97, No. 5, pp. 152–153; No. 6, pp. 187–189, 1908.

Describes areal geology and each of three types of remarkably rich ore deposits.

Übersicht über die nutzbaren Lagerstätten Südafrikas. By F. W. VOIT. (Concluded from p. 145.) Zeit. f. Prakt. Geol. Jg. XVI., H. 5, 1908, pp. 191–216, with plate II. and figs. 39–46.

Classifies the ores according to Beck and Bergeat, and describes every subdivision in detail.

The Genesis of Bendigo and Carrick Lodes, Otago, New Zealand. By J. PARK. Min. and Sci. Press. Vol. 97, No. 4, pp. 121–122, 1908.

Practically an abstract of Bull. 5, New Zealand Geol. Surv. Primary ore attributed to ascending magmatic emanations; superficial, rich ore due to downward concentration accompanying weathering and denudation.

Mineral Production of China in 1907. By T. T. READ. E. and M. Jl. LXXXV., No. 26, 1908, pp. 1286–1298.

Shows that extent and production are but vaguely known. Gives summary account of production of principal resources.

The Montezuma Mining District. By E. A. RITTER. Mines and Mining, June, 1908. Pp. 501–504.

Mineral Production of New York. By D. H. NEWLAND. Eng. & Min. Jl. Vol. 85, No. 20. 1908. Pp. 1007–1008.

Mining in the Province of Quebec for year 1907. Can. Min. Jl. XXIX., No. 11. Pp. 228–230.

Report on a Portion of Northwestern Ontario Traversed by the National Transcontinental Railway between Lake Nipigon and Sturgeon Lake. By W. H. COLLINS. Canada Dept. of Mines, Geol. Surv. Branch. No. 992. Pp. 23, with map. Ottawa, 1908.

The Mining Districts of Central Peru. By J. C. PICKERING. Eng. & Min. Jl. Vol. 85, No. 20. 1908. Pp. 997–1001.

Mining in the Eastern Townships of Quebec. By F. CIRKEL. Can. Min. Jl. XXIX., No. 11. Pp. 230–231.

Mineral Locations on Moresby Island—One of the Queen Charlotte Islands. (Abstract of Bull. No. 1, issued by British Columbia Bureau of Mines.) Can. Min. Jl. Vol. XXIX., No. 10, pp. 196–199; No. 11, pp. 236–238.

MINING LAW.

Mining Law. By C. H. SHAMEL. (Letter discussing an editorial of March 14 in the Min. & Sci. Press, XCVI., No. 21, 1908, pp. 696–697, further discussed by C. De Kalb, No. 22, pp. 732–733.)

Short Talks on Mining Law, II. By A. H. RICKETTS. Eng. & Min. Jl. Vol. 85, No. 21. 1908. Pp. 1037–1038.

Short Talks on Mining Law. By A. H. RICKETTS. E. and M. Jl. Vol. 83, No. 2, pp. 81–82.

Explains meaning of certain terms; considers right of location, and expenditures or assessment work.

Short Talks on Mining Law. By A. H. RICKETTS. E. and M. Jl. Vol. 86, No. 3, pp. 117–119.

Takes up actual discovery of mineral, marking the location, the identification of the claim, when the location is complete, record of failure to contribute, and the right of possession.

By A. H. RICKETTS. E. and M. Jl. Vol. 86, No. 6, 1908, pp. 281–282.

Considers elements of veins and lodes and rights of owners.

Discovery before Location. By R. W. RAYMOND. Can. Min. Jl. Vol. 29, No. 12, p. 261, 1908.

Discusses United States and Ontario laws regarding discovery before location. Does not favor present Ontario law.

Mining Claims on Forest Reserves. Min. and Sci. Press. Vol. 96, No. 26, pp. 887–888.

A draft for a memorial to Congress, voicing complaints against the present system of inspection of mining claims located under the mineral land laws of the United States.

Official Statement Concerning the Projected Revision of Mexican Mining Law. By O. MOLINA. Min. and Sci. Press. Vol. 97, No. 5, pp. 135–136, 1908.

Discusses proposal to extend restrictions on foreign rights to all the states and frontier territories.

BIBLIOGRAPHY.

A Partial Bibliography of Publications Referring to the Geology and Mineral Resources of Alberta, British Columbia, and the Yukon. By J. C. GOILLIM. Can. Min. Jl. Vol. XXIX., No. 10, pp. 210–211; No. 11, pp. 242–243.

Die Geologische und Mineralogische Literatur des Nördlichen Harzvorlandes und des Harzes. III. Abt. Die Literature von 1904 und 1905 sowie Nachträge und Zusatze zu Abt. I und II. By E. SCHUTZE. Mitt d. Naturw. Vereins zu Magdeburg. 1904–1907. Pp. 120. Magdeburg, 1907.

Verzeichniss der Mineralogischen, Geologischen, Urgeschichtlichen und Hydrologischen Literature von Württemberg, Hohenzollern und den Angrezenden Gebieten. By E. SCHUTZE. 1 Beil. z. d. V. f. vaterl. Naturkunde in Württemberg. 64, 1908. Pp. 251. Stuttgart, 1907.

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Conservation of Ores and Minerals. By ANDREW CARNEGIE. Eng. & Min. Jl. Vol. 85, No. 21. 1908. Pp. 1051–1053.

Current Monthly Reports of Mines. By H. S. DENNY. Eng. & Min. Jl. Vol. 85, No. 23. 1908. Pp. 1134–1136.

Organization, Equipment and Operation of the Structural-Materials Testing Laboratories at St. Louis, Mo. By R. L. HUMPHREY, with preface by J. A. HOLMES. U. S. G. S. Bull. 329. Pp. 84, illustrated, 6 x 9 in.; paper. Washington, 1908, Government Printing Office.

SCIENTIFIC NOTES AND NEWS[1]

Mr. F. G. CLAPP, for a number of years geologist for the United States Geological Survey, engaged in investigations and preparation of reports on coal, oil, gas, and artesian waters, has resigned from the service, in order to take up the expert practice of geology and allied branches of engineering. For this purpose a partnership has been formed with A. W. Bee, Jr., civil engineer, under the name of Clapp and Bee, geological engineers, with headquarters in Pittsburg.

MR. LLOYD B. SMITH, instructor in the Pennsylvania State College School of Mines, has accepted a position with Spurr & Cox (Inc.).

A COMPLETE TOPOGRAPHIC and GEOLOGICAL survey of the properties of the Helvetia Copper Company, near Tuscon, Arizona, is being made by Spurr & Cox, Inc. The party consists of J. E. Spurr, J. H. Farrell, W. D. Blackburn and Lloyd B. Smith.

MR. HORACE V. WINCHELL has resigned his position as chief geologist for the Great Northern Railway Co., and has opened an office for general practice at Minneapolis, Minn. He will devote special attention to copper and iron ore mines and mining litigation. His cable address is *Racewin*. His address will be Minneapolis, Minn.

PROF. J. VOLNEY LEWIS is preparing a report for the Geological Survey of New Jersey on the stone industry of the state, with special reference to materials adapted to architectural and engineering uses.

[1] Geologists, mining engineers and others interested in applied geology are invited to keep the editor informed of new investigations of mining districts or scientific studies undertaken by them, together with such other scientific and personal items as may come to their notice.

AT THE UNIVERSITY OF NEVADA, the new mining building and the statue of John W. Mackay, both the gift of Clarence H. Mackay and his mother, Mrs. John W. Mackay, were dedicated on commencement day. The building, erected at a cost of $75,000, is to house the departments of mining and metallurgy and of geology and mineralogy, ample accommodations being provided for all the work of these departments, besides a large museum room which occupies one wing. In addition to this, Mr. Mackay has promised other gifts of money to the university, for a part of the equipment and running expenses of the same departments, for extensive improvements of the campus, and for providing an athletic field and training quarters.

THE WORK of the United States Geological Survey is carried on by means of appropriations made each year by Congress, chiefly in the act providing for "sundry civil expenses of the Government" and popularly known as the Sundry Civil Bill. For the coming fiscal year—1908-9—this act appropriated for the Survey $1,335,520, specifying that the sum be applied to the following purposes:

Geologic surveys	$200,000
Paleontologic researches	10,000
Chemical and physical researches	20,000
Mineral Resources report	75,000
Topographic surveys	300,000
Forest reserve topographic surveys	75,000
Water-resources investigations	100,000
Structural-materials investigations	100,000
Fuel-testing investigations	250,000
Geologic maps, printing and engraving	100,000
Illustrations for reports	18,280
Books for library	2,000
Statutory and temporary salaries	85,240
	$1,335,520

An appropriation of $80,000 for the investigation of Alaskan mineral resources by the Geological Survey was carried in the deficiency bill, passed early in the spring.

An appropriation of $157,350, to be expended under the direction of the Secretary of the Interior, was also made in the Legislative Act for coal-mine inspection in the Territories and for

investigating the cause of mining accidents, and the work has been intrusted to the Survey.

Other appropriations, for rent of offices in Washington and for the publications, make the total for the work of the Survey exceed one and three-quarter million dollars.

Plans for carrying on the work provided for by these various appropriations are now in preparation and will soon be announced.

MR. G. H. COX, of the Wisconsin Geological and Natural History Survey, has been detailed to make a comprehensive study of the "oil rock" with which the lead and zinc deposits are associated.

PRELIMINARY TO THE field work of the present season the members of the Illinois Gological Survey met in conference at Urbana, June 19. Twenty-one persons were present. Methods of keeping uniform records, of making collections, and of sampling materials, were discussed in detail. The conference was followed by a luncheon at the University Club.

WALDERMAR LINDGREN, of the U. S. Geological Survey, has been appointed lecturer in economic geology at Massachusetts Institute of Technology, to succeed Prof. J. F. Kemp, of Columbia University.

PROF. CHAS. N. GOULD, head of the department of geology at the State University of Oklahoma, was elected director of the newly established Geological Survey of Oklahoma on July 25. The survey is provided for by the state constitution and the first legislature made an appropriation of $15,000 for the work. Professor Gould and his assistants are now in the field studying the oil, gas, building stone and road material resources of the state.

GEO. OTIS SMITH, director of the U. S. Geological Survey, is spending a portion of the summer visiting field parties in the western states. The Survey has opened an office in the Commonwealth Building, Denver, Colo., for the disbursing of accounts of western field parties and for the use of section chiefs, of the geologic, topographic and hydrographic divisions.

THE coal division of the U. S. Geological Survey, which is under the direction of M. R. Campbell, geologist in charge of economic geology of fuels and C. A. Fisher, principal assistant, is continuing this year the examinations of the western coal fields. The following fields are being examined, classified by Land Office subdivisions, and valued by the geologists: In Montana, vicinity of Havre by L. J. Pepperburg, Bull Mountains by R. W. Richards, Peek Indian Reservation by C. D. Smith, Livingston by W. E. Calvert. In Wyoming, Bighorn Basin by E. G. Woodruff, Buffalo and vicinity by H. S. Gale, Powder River and Wild Horse Creek by R. W. Stone, Rock Springs by A. R. Shultz, northeast of Rock Springs by E. E. Smith, southeast of Rock Springs by M. W. Ball. In Colorado, the Denver basin by G. C. Martin, M. I. Goldman, and C. W. Washburn, Trinidad by G. B. Richardson, and in New Mexico, the Rutan field by W. T. Lee.

"A HANDBOOK for Field Geologists in the United States Geological Survey" is the title of a recent publication of the Federal Survey, by C. W. Hayes, Chief Geologist. In Part I. are general instructions, with descriptions of various methods of geologic surveying, useful tables and formulæ. Part II. is instructions for special investigations. In it are described the observations that should be made in petrologic studies, in structural and glacial geology, in the investigation of precious and semiprecious metalliferous deposits, placer deposits, oil and gas fields; together with schedules for observations in pure and applied geology. It is a book which will be so thoroughly useful to the field geologist as to be his constant companion.

DR. HENRY S. WASHINGTON AND J. VOLNEY LEWIS, mining geologists, have removed their office from 95 Liberty Street, New York City to the Singer Building, 149 Broadway, Tel. 2168 Cortlandt.

ON THE DEATH of the late W. S. Yeates, State Geologist of Georgia, Professor S. W. McCallie, for a number of years the senior Assistant Geologist of the Survey, was appointed State Geologist. S. P. Jones, some years back Assistant State Geolo-

gist, who has recently been doing special work in petrography at the University of Wisconsin and at Sheffield Scientific School of Yale University, has been appointed Assistant State Geologist. The staff of the Survey now consists of S. W. McCallie, State Geologist, Otto Veatch, Assistant State Geologist, S. P. Jones, Assistant State Geologist, and Edgar Everhart, Chemist.

PRESIDENT VAN HISE, of the University of Wisconsin, was appointed by President Roosevelt to represent the National Association of State Universities at a conference on the conservation of natural resources held at the White House on May 13–15.

AT A MEETING OF THE GEOLOGICAL SOCIETY of Washington held at the Cosmos Club on Wednesday, April 8, 1908, Mr. W. H. Emmons read a paper on the "Secondary Enrichment in the Granite Bi-Metallic Mine, Philipsburg, Montana."

H. A. BUEHLAR has been elected Director of the Bureau of Mines and Geology of Missouri in the place of Dr. E. R. Buckley who has resigned to accept a position with the Federal Lead Co. Mr. Buehlar is a graduate of Wisconsin University and served for some time as Assistant State Geologist of Missouri, being joint author with Mr. Buckley of a report upon the Granby district and another on the quarrying industry of the state. He is also author of the recently issued report upon the cement materials of the state and is favorably known as a geologist of energy and ability, being especially interested in the chemical problems of the science. He has been employed for the last year by the Federal Lead Co.

AN ERRATA SHEET has been prepared to accompany Bulletin 5 of the State Geological Survey of Illinois, a Report upon the Water Resources of the East St. Louis District, written by Isaiah Bowman and Chester A. Reeds. This report went through the press during Mr. Bowman's absence in South America, and a large number of mistakes crept into the text. Copies of the errata sheet will be sent upon application to the State Geological Survey, Urbana, Illinois.

THE GEOLOGIC AND GEOGRAPHIC RECONNAISSANCE of Mindanao and the Sulu group under the direction of Warren D.

Smith, Chief of the Division of Mines, Bureau of Science has been completed. The work included a study of the gold-bearing districts of Cagayan de Misamis and Placer; exploration of the Rio Grande de Mindanao; the crossing of the island from Cotabato to Davao through the country of the Manobos; exploration of part of the hostile Moro country east of Lake Lanao; the ascent of Mt. Apo, the highest mountain in the Archipelago; investigation of the geology (chiefly coal) of the Zamboanga Peninsula. The illustrated narrative report of the expedition will soon appear in the *Journal of Science*. The scientific results will follow as material is worked up. The later chapters will be economic, petrographic, physiographic and paleontologic. The major part of this work was carried out with military escort.

MR. H. V. WINCHELL recently suffered from a fall in a shaft in Goldfield, Nev., but fortunately sustained no more serious injuries than a sprained ankle. This has disabled him for some time. He has now recovered, however, and his work has not been greatly retarded by this unfortunate accident.

A RECENT CIRCULAR from the Council of the Geological Society of America announces that the New Haven meeting has been abandoned and that the society will meet at Baltimore next December in conjunction with the American Association. A strong program is in prospect.

SECTION E OF THE A. A. A. S. held a meeting at Hanover, N. H., beginning June 29 last. The excursions were attractive and instructive.

MR. ARTHUR KEITH has been appointed to represent the U. S. Geological Survey in the proposed general committee on nomenclature. Dr. T. C. Chamberlain has been appointed to represent the Geological Society with Professor J. J. Stevenson as alternate. Other appointments will be announced later.

THE COMMITTEE ON MINES AND MINING of the House of Representatives at Washington has reported favorably on the Foster bill providing National aid for state and territorial mining schools similar to that now given agricultural colleges. They have also favorably reported a bill for establishment of a Bureau of Mines in the Department of the Interior.

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